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**NEW!**

# TRANSISTOR CIRCUIT GUIDEBOOK

By Byron Wels

# **Transistor Circuit Guidebook**

**Byron Wels**



**TAB BOOKS**  
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## Preface

I suppose my first experience with solid-state devices marks me (along with many other World War II GIs) as somewhat of a pioneer in the field. We were using solid-state receivers before the transistor was known. Unlike today's experimenter, with a choice of sealed, encapsulated, and very exotic devices with which to experiment, we had to construct our own semiconductors! Here's how we did it:

First, you swiped a pair of earphones from the nearest plane, jeep, or tank. Then you carefully took one of the phones apart and unwound the wire from the magnet inside. An empty toilet paper roll served as the coil form, which you wound full of wire, closely spaced. The remaining wire was strung out as high and as far as it would reach—for the antenna. After clipping the catch off a safety-pin, you stuck it into a hunk of wood so the point projected at right angles. Next, you needed a razor blade. Oh, none of the fancy plastic-coated, ribbons-of-steel, but a blued blade—quench-blued, mind you, not lacquer blued. It was placed so the point of the pin could contact it. A bayonet stuck hilt-deep in the ground served as a ground connector, and the other earphone was wired to blade, pin, and antenna coil. If you found the right spot on the blade's bluing, you could actually hear Tokyo Rose!

Regardless of your niche in the world of electronics, this collection of transistor and solid-state circuits should be right up your alley. It was compiled for those with an intense interest in circuit function and application. It is not a primer on the solid-state art—you won't have to wade through lengthy treatises; rather, it is a collection of basic and advanced design circuits covering the many fields of electronics. Each circuit is accompanied by a brief "non-technical" description of circuit highlights, and in most cases, several applications

are suggested, with the hope that many more will come to mind as you read and as occasions and needs arise.

For designers and technicians it is hoped many circuits will serve as typical examples. Certainly, technicians who acquire a familiarity with these circuits will be better able to cope with present and future equipment. For experimenters and construction-minded readers there is enough information, parts lists, component specifications, charts, coil data, etc.—to enable you to actually build or modify the circuit and get it operating. Amateur and hobbyist interests haven't been ignored, either. You'll find many made-to-order circuits for the home, office, ham shack, auto, etc.

The preparation of a book such as this necessitated the cooperation of many companies, who readily made their resources available. The author gratefully acknowledges the assistance offered by:

Microwave Associates  
Motorola, Inc.  
RCA  
Radio Shack  
Texas Instruments

The author also wishes to express appreciation to his father for the encouragement given him during his early ventures into what must have appeared, at that time anyway, as a hopeless and useless vocation. To thank him in some small measure, I respectfully and lovingly dedicate this book to:

Joseph Wels

Byron G. Wels

New York, N.Y.  
1968

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## TUNER AND RECEIVER CIRCUITS

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### RF Booster

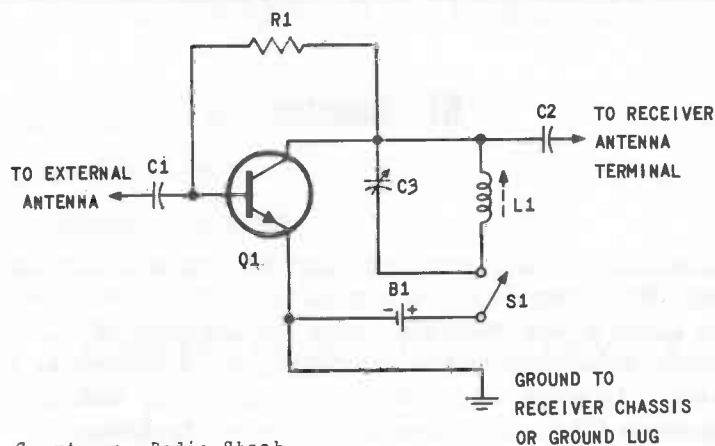
In spite of its obvious simplicity this RF amplifier circuit is capable of boosting very weak signals to a usable level. While it can serve at any frequency within the tolerance of Q1, this circuit's widest application, perhaps, is as a receiver RF booster. To adapt the circuit to a specific use, tank circuit components C3-L1 must tune to the desired frequency.

The greatest advantage of this circuit is that it provides an expedient means for attaching an external antenna to equipment not originally designed for such use. It must be pointed out, though, that the effectiveness of the amplifier depends on antenna efficiency. With a small or inefficient antenna, the resulting signal-to-noise ratio will be quite low.

Chances are that you will want to use a unit like this with a transistor radio. For that matter, it can be used with any broadcast band receiver, whether or not it is equipped with antenna terminals. If your receiver does have an antenna jack, by all means use it. If it hasn't, then try this simple trick: If the receiver antenna is a ferrite type, obtain one just like it and attach its terminals between C2 and ground. Then tape it as close as possible to the receiver's antenna, similarly aligned. You can use the same method with a loop-type BCB receiver antenna. If your little transistor receiver has a long ferrite antenna with all the coil winding at one end, try winding a few turns of wire around the other end and connect these to the booster, thus inducing more signal in the ferrite rod itself.

To use the unit, tune to a station near the middle of the band. Adjust C3 for maximum volume, turning down the receiver's

volume control as needed. Then adjust the core of the loopstick L1 for additional gain. From then on, you should not have to adjust L1 for any other station on the band, just remember to turn the booster off when you turn off the receiver!



Courtesy: Radio Shack

#### PARTS LIST

##### TRANSISTOR:

Q1—2N166

##### CAPACITORS:

C1, 2—.01 mfd

C3—365 pfd

##### RESISTOR:

R1—36K

##### BATTERY:

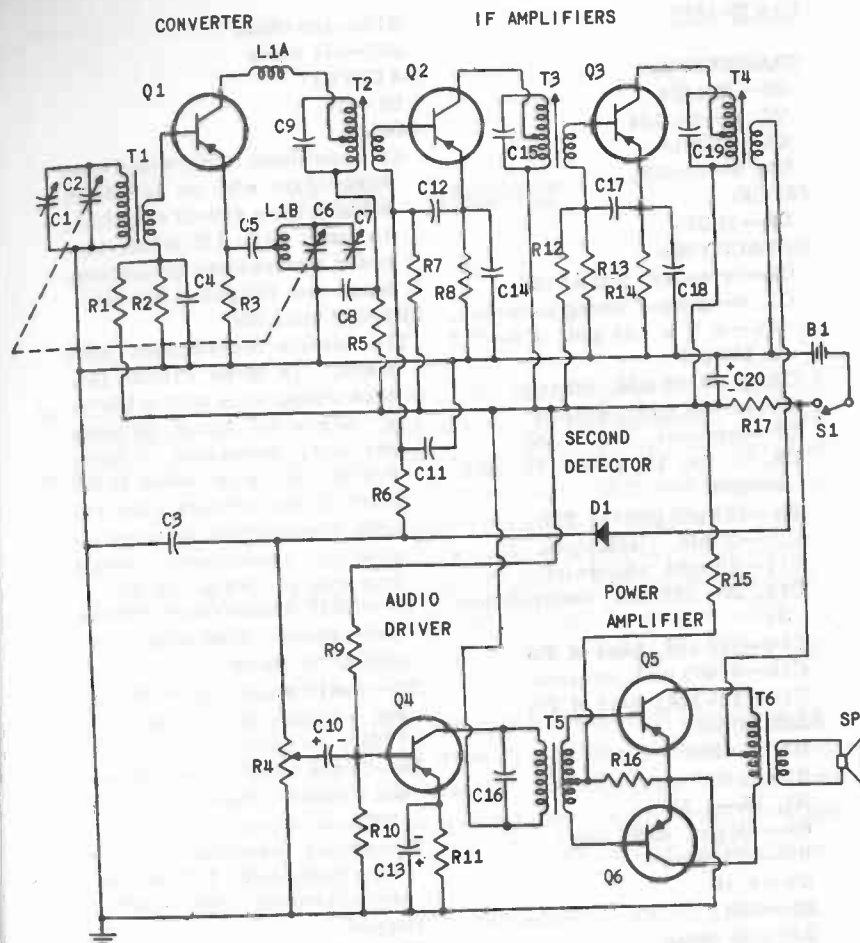
B1—1.5v

##### COIL:

L1—broadcast band loopstick

## 3-Volt Portable Receiver

Operating on a mere 3 volts, this fully-transistorized portable broadcast-band receiver is a classic in circuit design. While its performance might be improved by the addition of an extra RF amplifier, or an additional IF stage, these would be of no benefit in our search for basic operating information.



Courtesy: RCA

The antenna is formed on a ferrite bar, with the input coil actually forming a part of the antenna. Really, an updated version of the old BCB receiver loops. Frequency selection is accomplished by means of dual-gang tuning capacitor C2-C6. The input signal is applied to the converter stage (base of 2N1526) and the local oscillator signal is injected via C5 in the emitter circuit. C6 and L18 function as the oscillator tank. Heterodyning takes place in the converter, with the intermediate frequency signal appearing at the converter col-



## PARTS LIST

### TRANSISTORS:

- Q1—2N1526
- Q2, 3—2N1524
- Q4—2N2614
- Q5, 6—2N408

### DIODE:

- D1—1N295

### CAPACITORS:

- C1—trimmer, 3 to 15 pfd
- C2, 6—ganged tuning capacitor,
- C2—9.5 to 141 pfd; C6—7.2 to 109 pfd
- C3, 4—0.02 mfd, ceramic
- C5—0.005 mfd, ceramic
- C7—trimmer, 3 to 20 pfd
- C8, 12, 14, 17, 18—0.05 mfd, ceramic
- C9—128 pfd (part of T2)
- C10—2 mfd, electrolytic, 3v
- C11—10 mfd, electrolytic, 3v
- C13, 20—100 mfd, electrolytic, 3v
- C15—125 pfd, (part of T3)
- C16—0.005 mfd, ceramic
- C19—125 pfd, (part of T4)

### RESISTORS:

- R1, 9—10K
- R2—3.9K
- R3, 15—1.5K
- R4—5K pot, audio taper
- R5—470 ohms
- R6—6.8K
- R7—39K
- R8—330 ohms,
- R10—2.7K
- R11—270 ohms
- R12—10K
- R13—2.2K
- R14—240 ohms

R16—100 ohms

R17—47 ohms

### BATTERY:

- B1—3v

### COILS:

- L1—oscillator coil; wound from #3/44 Litz wire on coil form suitable for a #10-32 slug; L1A, 19 turns; L1B, 155 turns, tapped at 8 turns from ground end, tunes with 100 pfd at 990 kHz

### TRANSFORMERS:

- T1—antenna transformer; primary, 110 turns #10/41 Litz wire wound on a 3/4" x 1/8" x 4" ferrite rod (pitch, 50 turns per inch); secondary, 6 turns #10/41 Litz wire wound at the start of the primary; Q—100 with transformer mounted on chassis; transformer should tune with 135 pfd at 535 kHz
- T2—1st IF transformer; Thompson - Ramo - Wooldridge EO-13550, or equiv.
- T3—2nd IF transformer; Thompson - Ramo - Wooldridge EO-13551, or equiv.
- T4—3rd IF transformer; Thompson - Ramo - Wooldridge EO-13552, or equiv.
- T5—driver transformer; primary impedance, 10K; secondary impedance, 2K, center-tapped
- T6—output transformer; primary impedance, 100 ohms, center-tapped; secondary impedance, 15 ohms (to match voice-coil impedance of 12 to 15 ohms)

lector. Interstage transformer T2 couples the IF signals to the base of the first (or input) IF stage.

After two stages of IF amplification, the signal is rectified by the second detector diode 1N295 and fed through volume control R4 to the base of the audio driver. Notice that transformer coupling is employed between the driver and output stage. AVC voltage, developed across R6 and C11, varies the bias on the base of the first IF amplifier.

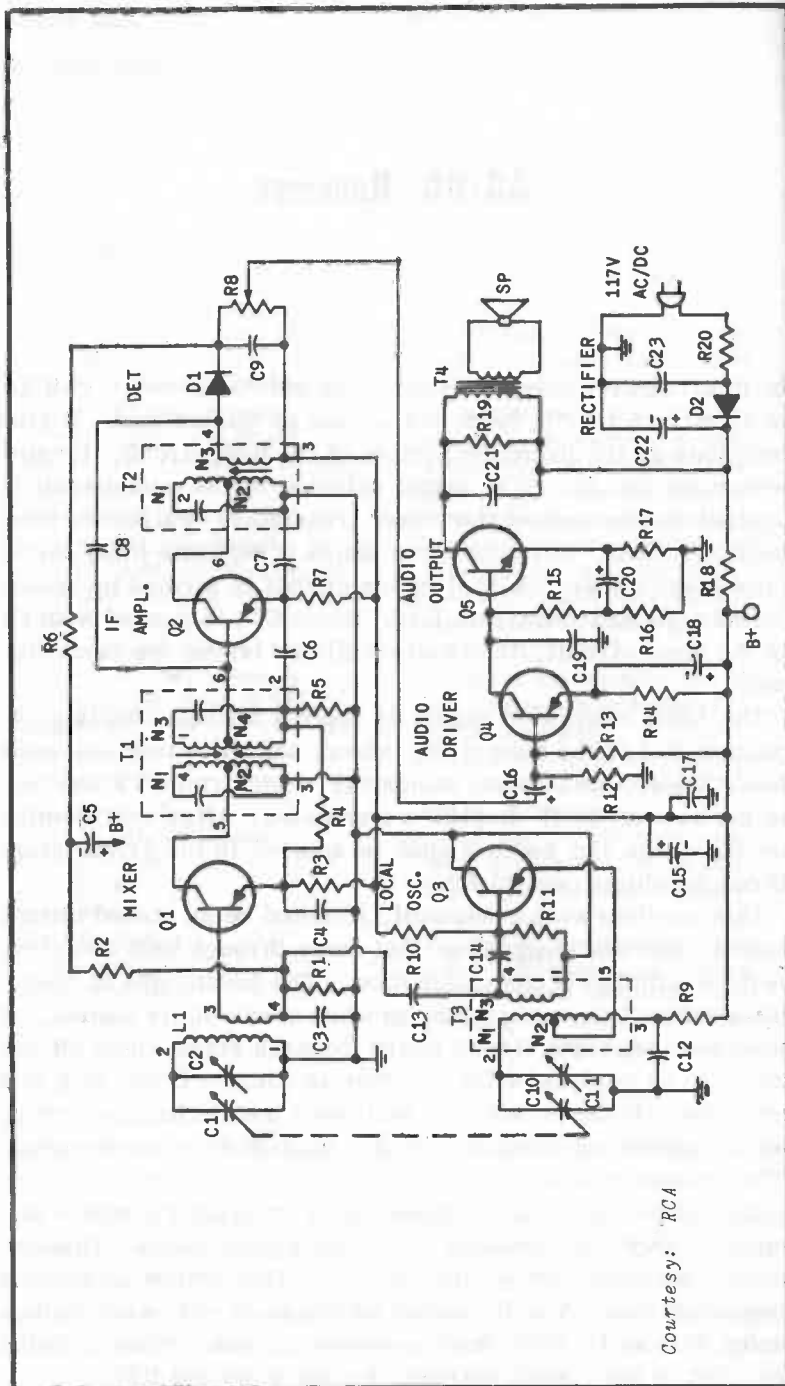
## AC/DC Receiver

In this transistorized version of the old "5-toober," coil L1 is wound on a ferrite form and serves as the antenna. It also functions as the inductive portion of the tank circuit, formed with capacitor C1. The signal selected by the tank circuit is applied to the base of the mixer transistor. Unlike the preceding circuit, this schematic shows a separate local oscillator stage whose resonant tuning circuit is formed by transformer T3 and capacitor C10. Since C10 is ganged with C1 in the input circuit, the local oscillator tracks the input signal.

The local oscillator signal is applied through coupling capacitor C13 to the base of the mixer, and the mixer collector feeds the 455-kHz output to input IF transformer T1 and then to the base of the IF amplifier transistor. After rectification by the diode the audio signal is applied to the driver stage through volume control R8.

This receiver works very well, mounted on an etched circuit board, and one suggestion that came through loud and clear is the possibility of modularization. The advantages of modular construction really show up when servicing is needed. If you have a separate circuit board for each stage, then all you need do to replace a faulty stage is remove it and plug in a new one. If the receiver is built on a metal chassis serving as the ground or common circuit, caution must be observed. The chassis may be hot.

One addition we'd like to make on all transistor circuits that operate from AC sources is a small pilot lamp. This can easily be added across the AC line. That brings up another important point: You'll find that adding an on-off switch makes using this unit a little more convenient, too. Place it in the hot side of the circuit between the line cord and R20.



Courtesy: RCA

## PARTS LIST

### TRANSISTORS:

- Q1—40487
- Q2—40489
- Q3—40488
- Q4—40490
- Q5—40491

### DIODES:

- D1—1N295
- D2—40495

### CAPACITORS:

- C1, 2, 10, 11—ganged tuning capacitor; antenna section (C1 + C2), 10 to 228 pfd; oscillator section (C10 + C11), 9 to 118 pfd
- C3—0.005 mfd, ceramic disc
- C4, 6, 7, 12, 17—0.05 mfd, ceramic disc
- C5—10 mfd, electrolytic, 3v
- C8—6.8 pfd, NPO ceramic
- C9—0.02 mfd, ceramic disc
- C13—0.001 mfd, ceramic disc
- C14—200 pfd, ceramic disc
- C15—100 mfd, electrolytic, 25v
- C16—10 mfd, electrolytic, 12v
- C18—100 mfd, electrolytic, 10v
- C19—0.047 mfd, ceramic disc
- C20—10 mfd, electrolytic, 10v
- C21, 23—0.01 mfd, ceramic disc 300v
- C22—100 mfd, electrolytic, 150v

### RESISTORS:

- R1—270K
- R2—1K
- R3—820K
- R4—2.2K
- R5—82K
- R6—18K
- R7—680 ohms
- R8—2.5K pot, audio taper
- R9, 11—6.8K
- R10, 12—22K
- R13—4.7K
- R14—560 ohms
- R15—1.5K
- R16—180 ohms
- R17—270 ohms
- R18—5.6K
- R19—10K
- R20—250 ohms

### COIL:

L1—antenna coil; core material, Ferramic Q or equiv; primary, 120 turns #32 wire wound 43 turns per inch; secondary, 5 turns of #34 wire; output impedance, 260 ohms at 1500 kHz; primary inductance, 0.413 uH at 790 kHz; unloaded Q, 125 at 600 kHz and 130 at 1400 kHz

### TRANSFORMERS

T1—first IF (455 kHz) transformer (includes 110-pfd capacitors across primary and secondary windings); turns ratio of tapped primary,  $N1/N2 = 3.16$ ; turns ratio of tapped secondary,  $N3/N4 = 33.4$ ; primary unloaded  $Q = 80$ , primary loaded  $Q = 75.68$ ; secondary unloaded  $Q = 80$ ; secondary loaded  $Q = 64$ ; input impedance = 14.55K coefficient of coupling = 0.85; Thompson-Ramo-Wooldridge # EO-22646, Automatic # EX-15267, or equiv.

T2—second IF (455 kHz) transformer (includes 110-pfd capacitor across primary winding); turns ratio of tapped primary,  $N1/N2 = 2.57$ ; turns ratio of lower section of primary to secondary,  $N2/N3 = 3.36$ ; unloaded  $Q = 80$ ; loaded  $Q = 35.2$ ; input impedance = 18K; Thompson-Ramo-Wooldridge # EO-22645, Automatic # EX-15267, or equiv.

T3—oscillator coil: turns ratio of full primary to section of primary below tap,  $N1/N2 = 26$ ; ratio of full primary to secondary,  $N1/N2 = 9.6$ ; full primary tunes with 100-pfd capacitance at 990 kHz; Automatic # E-6181A65-51, or equiv.

T4—audio output transformer; primary impedance, 2.5K; secondary impedance, 3.2 ohms; Triad # S-12X, or equiv.



## FM IF Amplifier

Since the function of the IF strip is to amplify the heterodyned signal, the more amplification you get, the better. But there's a law of diminishing returns here. It may be true that you want a lot of amplification, but it's got to be faithful amplification to do you any good at all. Obviously, a compromise must be worked out between sufficient amplification and adequate quality to avoid the possibility of distortion and downgrading of the signal.

### PARTS LIST

#### TRANSISTORS:

Q1, 2, 3—40245 or 40246

#### DIODES:

D1, 2—1N542 (matched)

D3—1N295

#### CAPACITORS:

C1, 4—4.7 pfd, ceramic disc

C2, 5, 8—0.01 mfd, ceramic disc

C3, 6—1000 pfd, ceramic disc 1000v

C7—5 pfd, ceramic disc

C9—1.0 pfd, ceramic disc

C10, 11, 12—330 pfd, ceramic

C13—0.05 mfd, ceramic disc

C14—0.02 mfd, ceramic disc

C15—5 mfd, electrolytic, 10v

#### RESISTORS:

R1, 5, 9—12K

R2, 6, 10—2.7K

R3, 4, 7, 8, 11—220 ohms

R12—470 ohms

R13—68 ohms

R14—22K

R15—3.9K

R16—1K

R17—1.5K

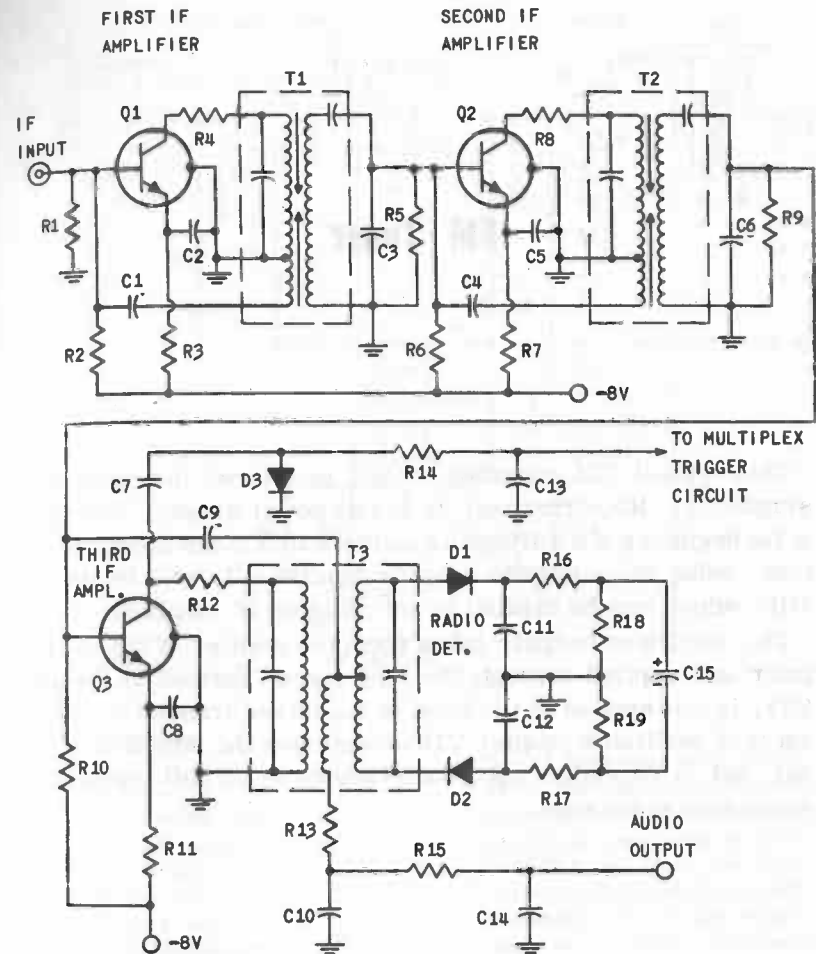
R18, 19—6.8K

#### TRANSFORMERS:

T1—second IF (10.7 MHz) transformer, Thompson - Ramo - Wooldridge # E019310-R2 or equiv.

T2—third IF (10.7 MHz) transformer, Thompson - Ramo - Wooldridge # E019311-R1 or equiv.

T3—ratio detector transformer, Thompson - Ramo - Wooldridge # E019312-R3 or equiv.



Courtesy: RCA

This circuit, which does an excellent job of satisfying quality and performance criteria, provides three stages of amplification and a ratio detector, consisting of two matched diodes. This circuit also is equipped for the addition of a multiplex adapter. The multiplex trigger is tapped off at the collector of Q3. With a multiplex unit attached, you will obtain a dual audio output for application to a stereophonic amplifier circuit and a pair of loudspeakers. The tuner in the following circuit and the multiplex unit presented later is a good combination for excellent stereo FM reception.

## FM Tuner

This typical FM superhet circuit is offered for its basic simplicity. Requiring only an 8-volt power supply, this unit is the beginning of a worthwhile addition to a home stereo system, using the multiplex adapter described later. Its 10.7-MHz output may be applied to any suitable IF amplifier.

The oscillator output, taken from the emitter of the oscillator and applied through the tank circuit formed by T4 and C17, is also applied to the base of the mixer transistor. The value of oscillator coupler C18 determines the injection voltage and is dependent upon such factors as circuit layout and component placement.

### PARTS LIST

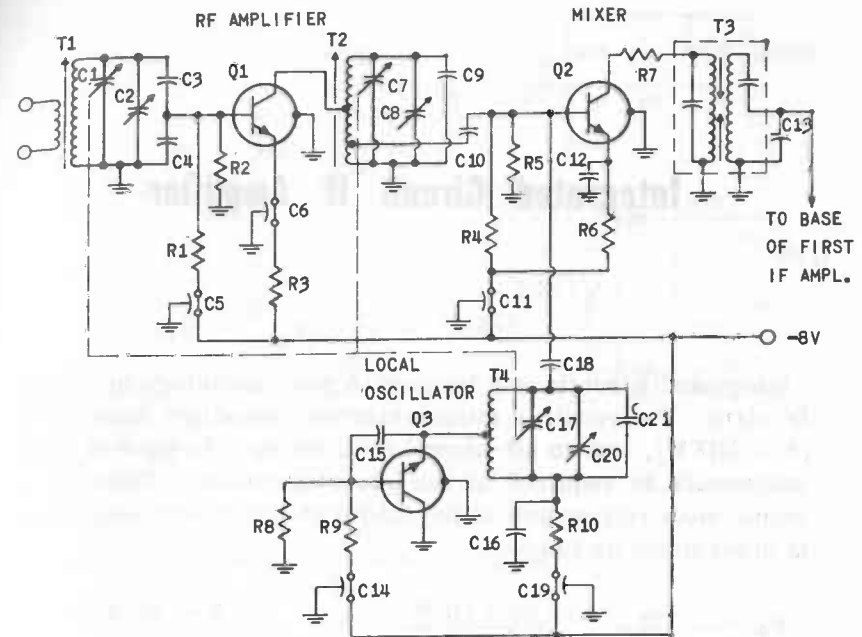
#### TRANSISTORS:

Q1—40242  
Q2—40243  
Q3—40244

#### CAPACITORS:

C1, 7, 17—ganged tuning capacitors, C1, 7 = 7.25 to 19 pfd; C17 = 6 to 21 pfd  
C2, 8—trimmer capacitor (part of ganged tuning capacitor assembly), approximately 17 pfd maximum  
C3, 9—5.6 pfd, miniature ceramic

C4—27 pfd, ceramic disc  
C5, 6, 11, 14, 19—feed-through capacitor, 1000 pfd  
C10—2000 pfd, ceramic disc, 1000v  
C12—0.01 mfd, ceramic disc  
C13, 16—1000 pfd, ceramic disc, 1000v  
C15—3.3 pfd, NPO ceramic  
C18—0.22 pfd to 3.3 pfd  
C20—tubular trimmer capacitor, 1.5 to 10 pfd  
C21—12 pfd, ceramic disc



Courtesy: RCA

RF SECTION

#### RESISTORS:

R1, 4—3.3K  
R2, 5—18K  
R3, 6—330 ohms  
R7—100 ohms  
R8—8.2K  
R9—4.7K  
R10—1.5K

#### TRANSFORMERS:

T1—FM antenna transformer; slug-tuned; slug, 0.250" long, 0.181" in diameter, Arnold Type 1RN9 or equiv.; secondary, 4 turns of #22 bare-tinned copper wire wound with 1 wire-diameter spacing between adjacent turns or 7/32" outer-diameter coil form, resonates with 27-pfd capacitance at 100 MHz, impedance = 6.1K; primary, 2 turns of #30 Gripeze wire close wound below cold end of secondary and in same direction, impedance (includes shunting effect of RF amplifier biasing network) = 460 ohms

T2—RF interstage coil; 4 turns of #18 bare-tinned copper wire wound with approximately 1/8" spacing between turns on 5/16" diameter coil form (coil form is removed after coil is wound); resonates with 27-pfd capacitance at 100 MHz; impedance of full winding, 6.1K; input tap located so that impedance at tap = 590 ohms; output tap located so that impedance at input tap is 540 ohms with the transformer properly loaded  
T3—first IF (10.7-MHz) transformer, Thompson-Ramo-Wooldridge # E019309-R4 or equiv.

T4—oscillator coil; 3 1/2 turns of #18 bare-tinned copper wire wound with 3/22" spacing between turns on 7/32" diameter coil form (coil form is removed after coil is wound), center tapped.

## Integrated Circuit IF Amplifier

Integrated circuits can be used to good advantage in an FM IF strip. The result is miniaturization, excellent sensitivity ( $8 \mu\text{V}$  IHFM), and an all-around good set up. An input of 1500 microvolts is required at the interstage filter. The differential-mode voltage gain of the CA3028A into a 3000-ohm load is determined as follows:

$$V_g = \frac{-Y_r}{Y_o + Y_L} = \frac{35 \times 10^{-3}}{0.38 \times 10^{-3}} = 92.5 = 39.3 \text{ db}$$

This degree of voltage gain requires an input of approximately 15 microvolts at the base of the CA3028A differential amplifier. Even if a triple-tuned filter having a voltage insertion loss of 28 db is used in a low-gain front end, you'll have a receiver with a 5-microvolt IHFM sensitivity. If 26 db second-channel attenuation is permissible, IHFM receiver sensitivity is 3 microvolts. Audio output is 155 mv RMS for  $140 \mu\text{v}$ ,  $\pm 75 \text{ kHz}$  input 3 db below the transfer characteristic knee.

### PARTS LIST

#### ICs:

G1, 2—CA3028A

#### CAPACITORS:

C1—680 pfd

C2 to C7—.01 mfd

C8 to C11—56 pfd

C12, 13—330 pfd

C14—.001 mfd

C15—5 mfd

#### RESISTORS:

R1—47 ohms

R2—82 ohms

R3, 6, 14—1K

R4, 5—2K

R7—150 ohms

R8—4.7K

R9—10K

R10—68 ohms

R11, 12—6.8K

R13—68K

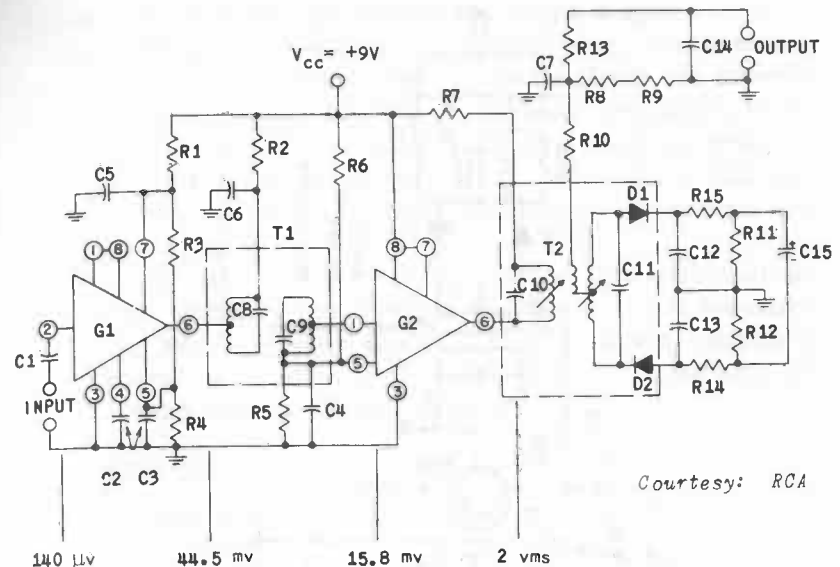
R15—1.5K

#### TRANSFORMERS:

T1—Interstage transformer

TRW #22486 or equiv.

T2—Ratio detector TRW #22516

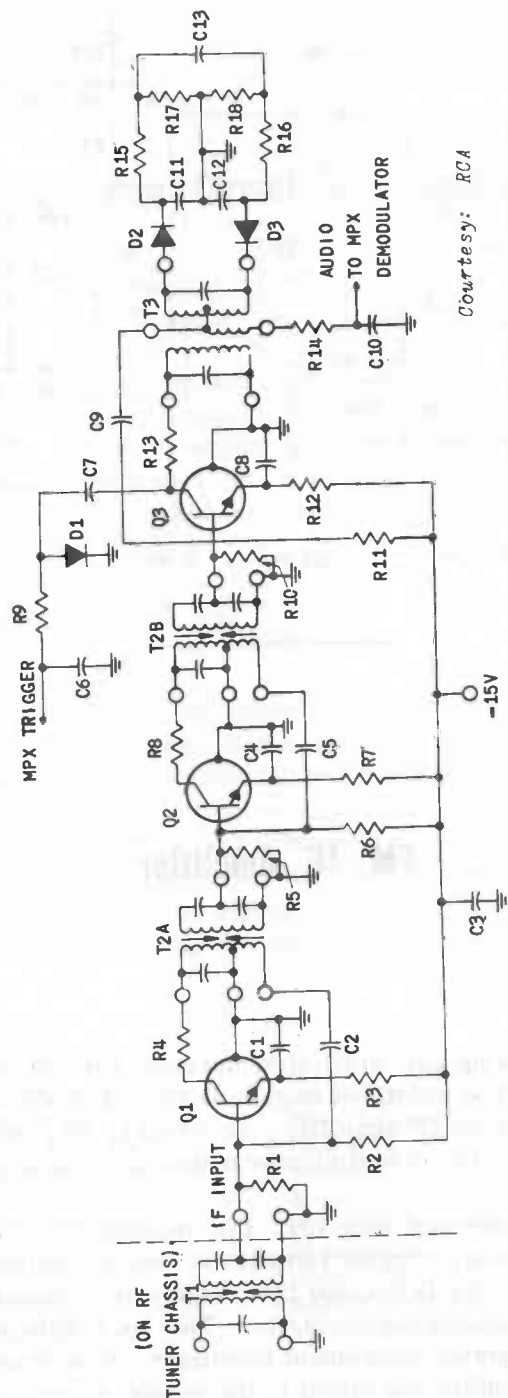


Courtesy: RCA

## FM IF Amplifier

If you're looking for an IF strip designed for FM multiplex, here you go! The multiplex trigger is taken (via C7) from the collector of the 3rd IF amplifier, rectified by D1, and shaped by C6 and R9. The discriminator output is fed to a multiplex demodulator.

In an FM tuner or receiver, the intermediate frequency amplifier section performs a number of useful functions. For one thing it is the IF section that largely determines the receiver selectivity characteristic. The 10.7-MHz output of any tuner is applied to the input terminals. Interstage transformer T2 couples the signal to the second stage of ampli-



Courtesy: RCA

cation, and then through T2(b) to the output stage.

Diodes D2 and D3, which are a matched pair, function as a ratio detector to demodulate the composite signal and provide audio which can be applied either to an audio amplifier, or to an amplifier through a cathode or (in this case) an emitter-follower. All resistors are 1/4 watt; .01- and .05-mfd capacitors are 50v ceramic discs, and 330-pfd capacitors are 1KV discs.

Additional selectivity is often designed into intermediate frequency transformers through the use of a Tschebychev coupling, which is overcoupled. This results in roughly a square-wave response with a depressed notch in the top, an area in which critical tuning can occur.

#### PARTS LIST

##### TRANSISTORS:

Q1, 2, 3—40481

##### DIODES:

D1—1N295

D2, 3—1N542

##### CAPACITORS:

C1, 3, 4, 8—.01 mfd

C2, 5—3.3 pfd

C6—.05 mfd

C7—5 pfd

C9—.68 pfd

C10, 11, 12—330 pfd

C13—5mfd, 10v

##### RESISTORS:

R1, 5—18K

R2, 6—3.3K

R3, 7, 13—470 ohms

R4, 8—220 ohms

R9—22K

R10, 11—8.2K

R12—1.8K

R14—68K

R15—1K

R16—1.5K

R17, 18—6.8K

##### TRANSFORMERS:

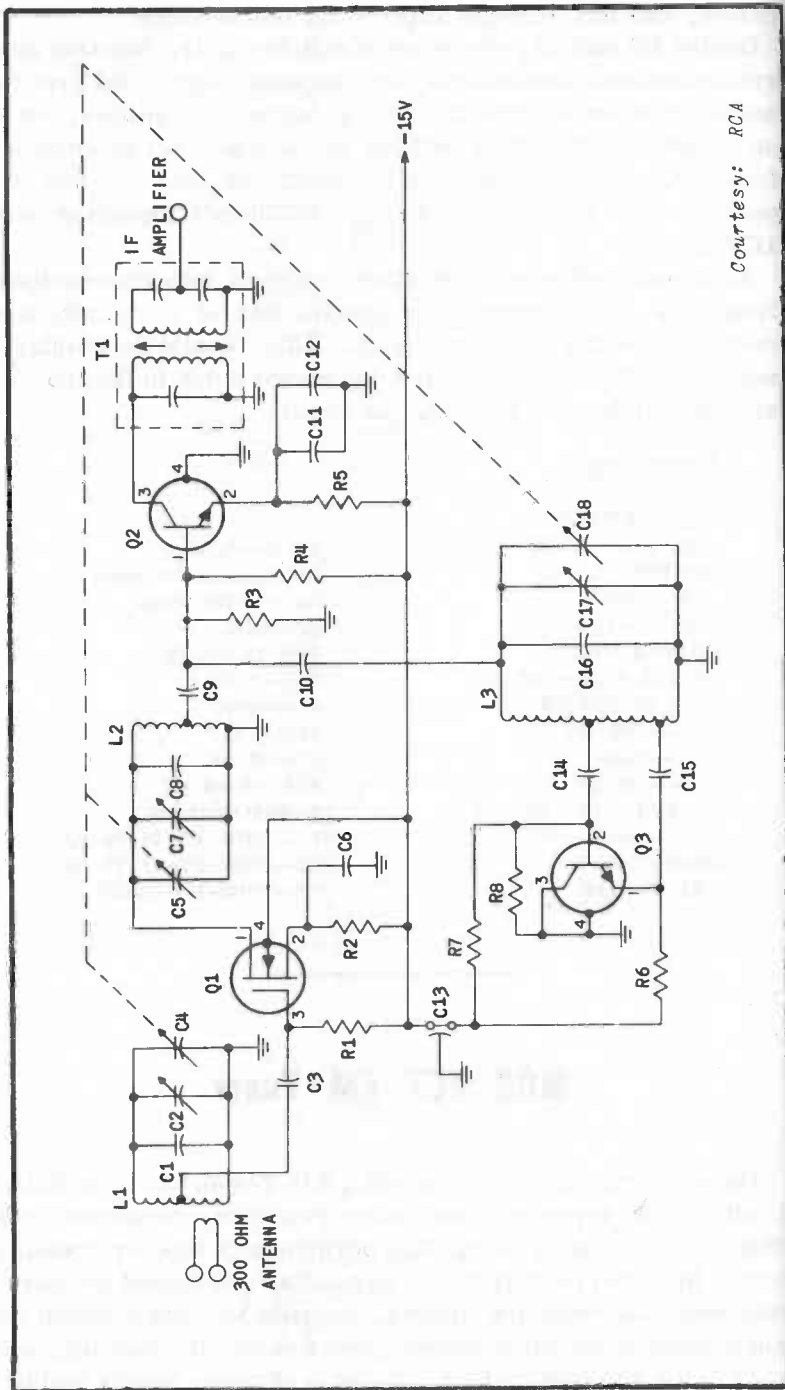
T1—TRW-EO-21124-RA

T2—TRW-EO-21125-R1

T3—TRW-EO-23023

## MOS FET FM Tuner

The performance of this circuit, with respect to sensitivity, limiting, IF rejection, and image rejection, compares with that of other tuners using high-performance bipolar transistors. Receiver performance, particularly in regard to spurious-response rejection figures, depends to a great extent on such things as physical layout, power supply decoupling, and care used in construction. Using a negative supply voltage



Courtesy: RCA

simplifies the matter of tuned circuit grounding and power supply decoupling.

This unit aims for the elimination of spurious response as a primary goal. Usually, a circuit having low spurious response is hard to reproduce. In some systems, circuit performance is a direct function of the operating points of the transistors selected. When the RF amplifier transistor was changed repeatedly, tuner performance remained consistently the same.

#### PARTS LIST

##### TRANSISTORS:

Q1—40468  
Q2—40479  
Q3—40244

##### CAPACITORS:

C1, 8, 16—16 pfd  
C2, 7—2-12 pfd, trimmer  
C3, 6—0.002 mfd  
C4, 5, 18—5.5-22.5 pfd, gang-  
ed tuning capacitor  
C9—5000 pfd  
C10—2.7 pfd  
C11—0.01 mfd  
C12, 14, 15—1000 pfd  
C13—1000 pfd feedthrough type  
C17—2-10 pfd, trimmer

##### RESISTORS:

R1—100K  
R2—220K  
R3, 4—47K  
R5—4.7K  
R6—8.2K  
R7—120K  
R8—22K

#### COILS:

L1 #18 bare copper wire, 4  
turns, 1/4" ID, 7/16" winding  
length, Q at 100 MHz = 130.  
Tunes with 34-pfd capacitance  
at 100 MHz. Antenna link ap-  
proximately 1 turn from ground  
end. Gate tap approximately  
1 1/2 turns from ground end.  
L2—#18 bare copper wire, 4  
turns, 1/4" ID, 7/16" winding  
length, Q at 100 MHz = 120.  
Tunes with 34-pfd capacitance  
at 100 MHz. Base tap approx-  
imately 3/4 turn  
L3— #18 bare copper wire, 4  
turns, 7/32" ID, 7/16" winding  
length, Q at 100 MHz = 120.  
Tunes with 34-pfd capacitance  
at 100 MHz. Emitter tap ap-  
proximately 1 1/2 turns from  
ground end. Base tap approx-  
imately 2 turns from ground  
end.

#### TRANSFORMER:

T1—IF transformer

The best correlation was found with the operating current of the transistor in the circuit. For the normal spread of operating current in this circuit (3.5 to 7 ma), the variation in rejection is about  $\pm 1$  db.

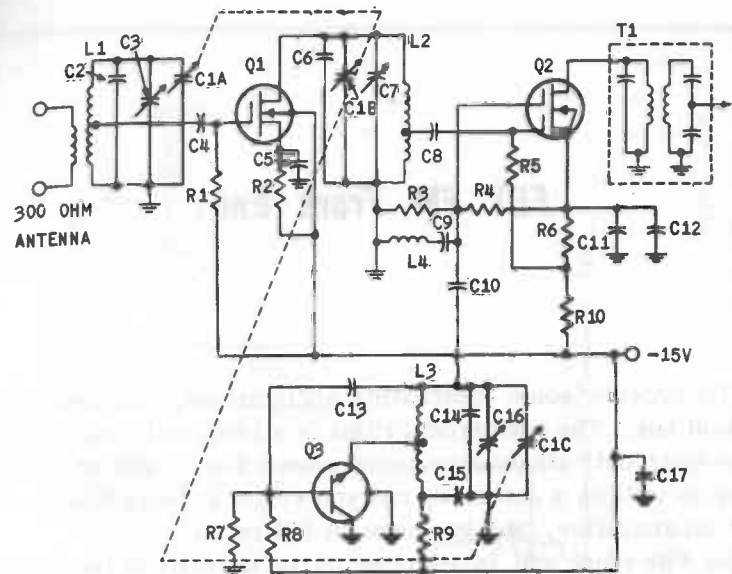
The 40468 MOS field effect transistor has been incorporated into this FM tuner; all other stages use high-performance, low-capacitance, bipolar types. The wider dynamic range of the MOS transistor provides significant improvements in the rejection of spurious response over that achieved previously with bipolar RF amplifiers.



## Dual-Gate MOS FM Tuner

Dual-gate MOS FETs are coming into their own, as this schematic indicates. This front end will operate with any FM IF schematic shown in this book. Should you decide to build, it's a good idea to shield the tuner from the balance of the circuit, and this can easily be accomplished by using double-sided copper-clad laminate for your layout. Etch the top of the board to accommodate all necessary components, and then simply etch away spot land areas on the reverse of the board where component lead wires pass through to the used foil side. Grounding the unsoldered side of the board permits it to act as an effective RF shield for the critical circuits. However, you must be sure that sufficient cladding is etched away so that no short circuits occur. As the components are passed through the ground cladding to the foil-soldered side, you will find an extra bonus in the ease with which transformer cans and coil shields can be grounded, simply by soldering to the ground foil.

If you want to wind the coils, tie an end of the wire to a convenient doorknob and then pull the wire taut. This slight stretching will take out any kinks or bends. To wind a spaced coil, tie two lengths of wire to the doorknob, and attach the far ends to your coil form. Wind them tight and close, walking toward the doorknob as you go to keep the wires tight. When the coil is completed, simply unwind the second coil and you will be left with a tightly-formed coil spaced the thickness of the wire. Coat the completed coil with polystyrene coil dope, and when it has dried, scrape the dope away to solder the taps into place.



Courtesy: RCA

### PARTS LIST

#### TRANSISTORS:

Q1—40468  
Q2—TA7151  
Q3—40244

#### CAPACITORS:

C1A, B, C—6-19.5 pfd ganged tuning capacitor (TRW #57-3A)  
C2—150 pfd NFO  
C3, 7, 16—2-14 pfd  
C4, 5, 15, 17—2000 pfd  
C6, 14—15 pfd NFO  
C8—5000 pfd  
C9—270 pfd  
C10—3 pfd NFO  
C11, 12—1000 pfd  
C13—3.3 pfd

#### RESISTORS:

R1, 5—100K  
R2—220 ohms  
R3—180K  
R4—12K  
R6—100 ohms  
R7—22K  
R8—56K

R9—4.7K

R10—220 ohms

#### COILS:

L1 (Antenna Coil)—#18 bare copper wire, 4 turns, 9/32" ID, 3/8" winding length, nominal inductance = 0.86  $\mu$ h, Q = 120, tapped approximately 1 1/4 turns from ground end, antenna link approximately 1 turn from ground end.

L2 (RF Interstage Coil)—#18 bare copper wire, 4 turns, 9/32" ID, 3/8" winding length, nominal inductance = 0.86  $\mu$ h, Q = 120, tapped approximately 1 1/2 turns from low end.

L3 (Oscillator Coil)—#18 bare copper wire, 3 1/4 turns, 9/32" ID, 5/16" winding length, nominal inductance = 0.062  $\mu$ h, Q = 120, tapped approximately 1 turn from low end.

L4—1  $\mu$ h RF choke

#### TRANSFORMER:

T1 (Input transformer to IF amplifier)—TRW #21124-R2

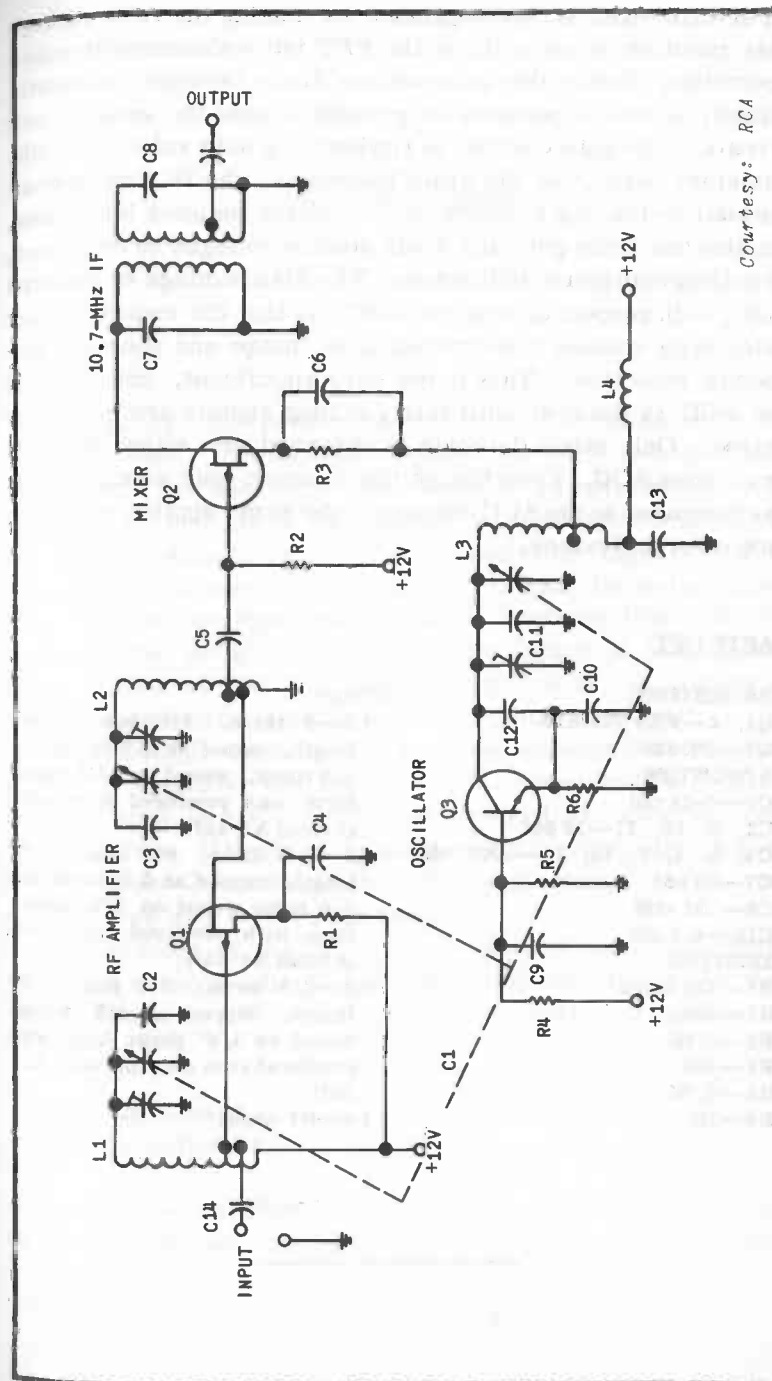
## FET FM Front End

FETs provide some interesting applications, and this is a typical one. The system described is a front end with a common-source RF stage using germanium FET. Add an FM IF strip as well as a detector, and you've got a dandy FM tuner. Add an amplifier, and you have an FM radio.

The FM front end is representative of many of the design problems encountered in many RF amplifiers and mixers. Of particular interest are power gain, signal-to-noise performance, and AGC characteristics. Also important are conversion gain, large-signal handling capabilities, and spurious response rejection. Consider the performance of the field-effect transistor in this circuit, with the unit tuned to 98 MHz:

Sensitivity for 30 db S + N/N at $\pm 75$ kHz deviation ..	2.7
Spurious response rejection (103.35 MHz).....	74
Image rejection (119.4 MHz).....	57
Tuner 6 db bandwidth.....	425
Tuner power gain (less 16 db loss/IF secondary)....	28.8
Oscillator injection EMF.....	490

Since the junction FET is operated in the depletion mode, it is usual to turn the device off to gain AGC action. This can be called "reverse AGC." However, forward AGC is not only possible but is often better in many respects than reverse AGC. Consider that gain reduction is caused only by reducing transadmittance. Once the device is cut off, further increases in AGC voltage do not continue to reduce the gain. One of the biggest advantages of reverse AGC is that little AGC power is needed. Another advantage is that the overall selectivity is not affected since the antenna and RF tank circuits experience very little change as AGC varies.



Courtesy: RCA

Forward AGC is accomplished by making the AGC voltage less positive so as to drive the FET into enhancement-mode operation. Since the gate-source diode becomes forward-biased, a low impedance is present across the antenna tank circuit. The gate current is limited to a safe value by a 20K resistor. Also, as the drain increases, the IR drop across the source-biasing resistor and the drain resistor increases, causing the drain gate and drain source voltages to decrease, providing additional AGC action. The disadvantage of forward AGC, with respect to reverse AGC, is that the reduced tuner selectivity causes a degradation of image and spurious response rejection. This is not very significant, however, if the AGC is delayed until fairly strong signals are being received. Only slight detuning is observed with either forward or reverse AGC. Even though the common-gate configuration has been used as the AGC example, the same applies for common-source devices.

#### PARTS LIST

##### TRANSISTORS:

Q1, 2—FED TXM12  
Q3—2N3826

##### CAPACITORS:

C1—6-21 pfd  
C2, 3, 10, 11—10 pfd  
C4, 5, 6, 9, 13, 14—.001 mfd  
C7—33 pfd  
C8—.01 mfd  
C12—4.7 pfd

##### RESISTORS:

R1—120 ohms  
R2—20K  
R3—5.6K  
R4—10K  
R5—2.7K  
R6—1K

##### COILS:

L1—3 turns, #18 bus, 5/16" length, tapped at 0.7 turns and 1.5 turns, wound on 1/4" paper form with powdered iron core (Arnold A1-13J).  
L2—2.5 turns, #18 bus, 1/4" length, tapped at 0.3 turns and 1.0 turns wound on 1/4" paper form with powdered iron core (Arnold A1-13J).  
L3—2.5 turns, #18 bus, 1/2" length, tapped at 0.3 turns, wound on 1/4" paper form with powdered iron core (Arnold A1-13J).  
L4—RF choke

## IC FM Tuner

Integrated circuits are used here to efficiently miniaturize an FM front-end. The CA3028A is used as an RF amplifier and converter. For best noise performance the differential mode is used and the base of the constant-current source is biased for a power gain of 15 db. The RF amplifier input circuit is adjusted for an insertion loss of 2 db to keep the noise figure low. Because the input transformer's insertion loss adds directly to the integrated circuit noise figure of 5.5 db, the noise figure for the front end alone is 7.5 db, as compared with a noise figure of about 6 db for commercial tuners.

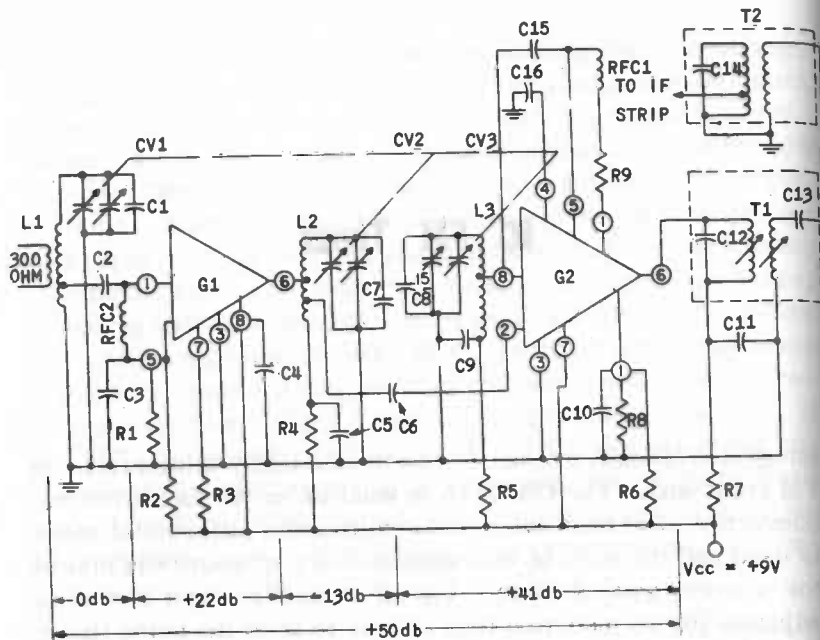
Though a single-tuned circuit is shown between the collector of the RF amplifier and the base of the converter, a double-tuned circuit is preferred to reduce spurious response from the converter. If the double-tuned circuit is critically coupled for the same 3 db bandwidth as the single-tuned circuit, insertion loss will remain the same.

The collector of the RF stage is tapped down on the inter-stage coil at approximately 1500 ohms and the base of the converter stage at 150 ohms. RF voltage gain is computed as follows:

Antenna to base..... 0 db  
Base to collector..... 22 db

If an IF converter transformer having an impedance of 10,000 ohms is employed, the calculated voltage gain is as follows:

$$VG_c = \frac{-Y_t}{Y_o Y_L} = 112 = 41.3 \text{ db}$$



Courtesy: RCA

#### PARTS LIST

##### ICs:

G1, 2—CA3028A<sub>3</sub>

##### CAPACITORS:

C1, 7—10 pfd

C2—470 pfd

C3, 4, 5, 6, 9, 10, 11, 16—.001 mfd

C8—15 pfd

C12—82 pfd

C13, 14—27 pfd

C15—1 pfd

##### RESISTORS:

R1, 6—1K

R2, 8—2K

R3—1.2K

R4—100 ohms

R5—47 ohms

R7—150 ohms

R9—50 ohms

##### COILS:

L1—3 3/4 turns, #18 tinned copper wire; winding length 5/16" on 9/32" form; tapped at 1 3/4 turns; primary—2 turns #30 SE

L2—3 3/4 turns, #18 tinned copper wire; winding length 5/16" on 9/32" form; tapped at 6 2 1/4 turns, A 3/4 turns.

L3—3 1/2 turns, #18 tinned copper wire; winding length 5/16" on 9/32" form.

CV1-2—variable  $\Delta C \approx 15$  pfd

CV1-3—variable  $\Delta C \approx 15$  pfd

RFC1, 2—1 uh choke

##### TRANSFORMERS:

T1—Mixer transformer TRW #22484 or equiv.

T2—Input transformer TRW #22485 or equiv.

Measured gain into the converter collector is 42 db. The measured voltage gain of the RF amplifier and converter into a 10,000 ohm load is 52 db. Calculated gain is 50 db.

## Varactor FM Tuner

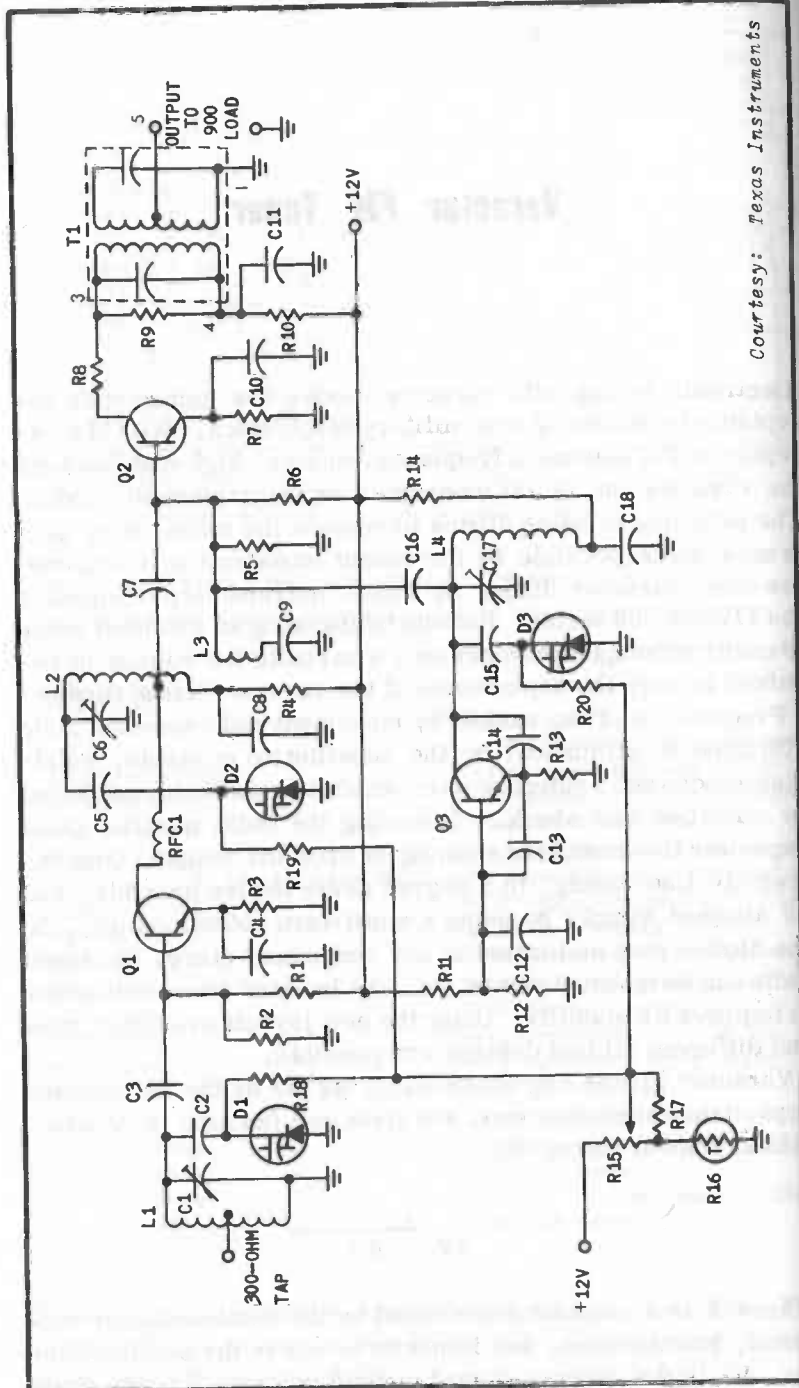
Electronic tuning with varactor diodes has gained wide acceptance in industrial and military electronics. With the exception of FM automatic frequency controls, high cost has kept the varactor out of the consumer or entertainment market. The principle of using diodes to replace the main tuning gang is now made possible by the recent introduction of uniform, low-cost varactor diodes by Texas Instruments, designated the TIV300-303 series. Remote tuning using an extended cable is easily accomplished since only a variable DC voltage is required to vary the capacitance of the reverse-biased diodes.

Frequency shifting caused by movement and capacitor plate vibration is eliminated by the substitution of stable, solid-state diodes and a potentiometer which is relatively unaffected by vibration and shock. Removing the bulky parallel-plate capacitor also results in a saving of size and weight. And extremely fine tuning, to a degree never before possible, can be attained simply by using a multi-turn potentiometer. As the diodes may be located in any convenient place, the tuned coils can be mounted where they are isolated from each other to improve RF stability. Using the new layouts available, new and different cabinet designs are possible.

Varactor diodes characteristics, as far as the PN junction capacitance are concerned, are given as a function of reverse-biased control voltage by:

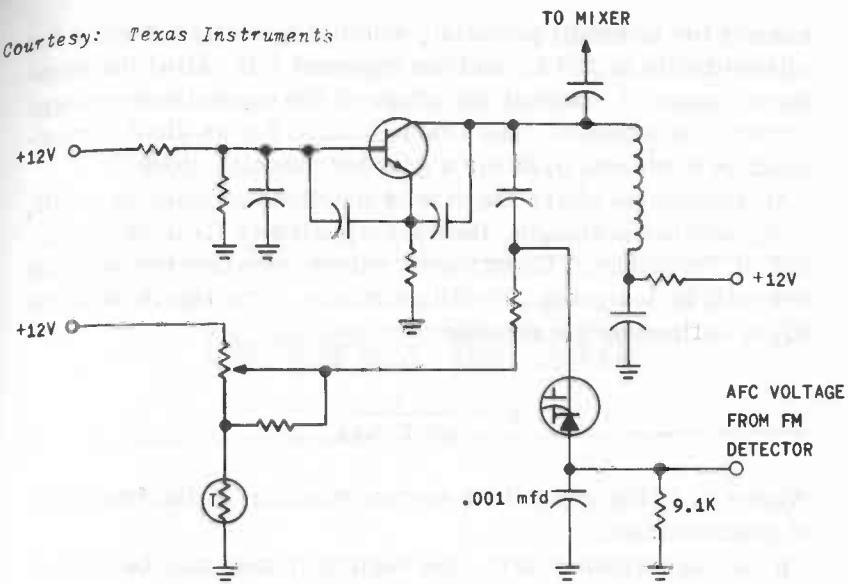
$$C_t = \frac{k}{(V_r + \phi)^n}$$

Where k is a constant determined by the semiconductor material, junction area, and impurity levels in the semiconductor.  $V_r$  is the reverse-biased control voltage;  $\phi$  is the diode



Courtesy: Texas Instruments

Courtesy: Texas Instruments



Oscillator Modification for AFC

**PARTS LIST**

**TRANSISTORS:**

- Q1, 3—2N4254
- Q2—2N4255

**DIODES:**

- D1, 2, 3—TIV301

**CAPACITORS:**

- C1, 6—ARCO 403 or equiv., 3.35 pfd
- C2, 4, 5, 8, 12, 15, 18—0.001 mfd
- C3—3.3pfd
- C7—12 pfd
- C9—240 pfd Dura Mica
- C10, 11—0.01 mfd
- C13—2.2 pfd
- C14—10 pfd
- C16—1.2 pfd
- C17—ARCO 400 or equiv., 0.9-7 pfd

**RESISTORS:**

- R1—4.7K
- R2, 3, 13—1K

- R4, 10, 14—330 ohms
- R5, 12—2.7K
- R6, 17—10K
- R7—820 ohms
- R8—270 ohms
- R9, 11—9.1K
- R15—100K pot linear
- R16 (Thermistor T1—TM 1/4)—2.7K
- R18, 19, 20—330K

**COILS:**

- L1—5 turns, #18 bus, 1/4" ID, 9/16" length, turns ratio 3.3:1
- L2—5 turns, #18 bus, 1/4" ID, 5/16" length, turns ratio 6.7:1
- L3—1 μh
- L4—4 turns, #18 bus, 1/4" ID, 1/2" length

RFC1—ferrite bead, RF choke

**TRANSFORMER:**

T1—TRW #21157—R1 or equiv.

contact (or internal) potential, which is typically 0.7 volts for silicon diodes at 25° C; and the exponent  $n$  is called the slope factor since it controls the shape of the capacitance-voltage curve. The exponent  $n$  has a value of 0.50 for an ideal abrupt-junction diode and 0.33 for a guarded-junction diode.

At frequencies where the size of the diode package is small, compared to wavelength, the total capacitance  $C_t$  is independent of frequency. Capacitance values measured at one kHz are valid in designing 100-MHz circuits. The figure of merit ( $Q$ ) is defined by the equation:

$$Q = \frac{1}{2 \pi f C_t r_s}$$

Where  $r_s$  is the equivalent series resistor at the frequency of measurement.

If you desire better AFC, the oscillator tank may be altered as shown on the modification diagram. This provides somewhat better AFC action at the low end of the band than at the high end.

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## AMPLIFIER CIRCUITS

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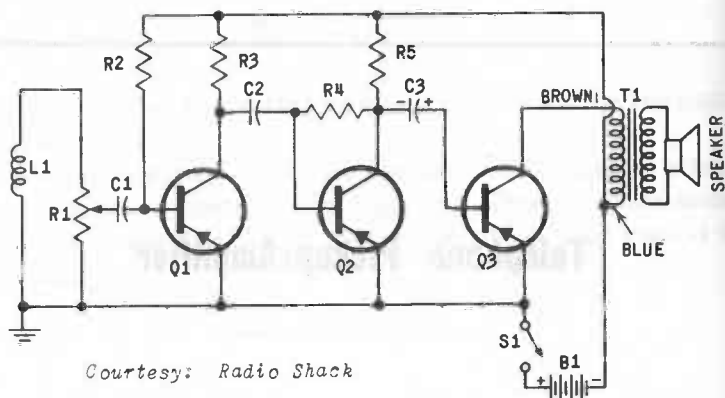
### Telephone Pickup/Amplifier

This is a straightforward 3-transistor amplifier circuit. Coil L1, the input, is one of the many ferrite core telephone pickups, and it is connected to the base of transistor Q1 through volume control R1 and coupling capacitor C1. Two additional stages of audio are provided, both capacitively coupled from collector to base. This circuit's primary application is telephone amplification, but it can be used in a number of ways. For example, you can mount the coil on a plastic wand and use it as a means of tracing down inductively generated noise in automobile engines. Or substitute a jack for the coil and any audio input can be used.

Units such as this have been used successfully to amplify both sides of a telephone conversation. However, don't expect it to amplify your own voice going into the telephone mouthpiece or transmitter. The author has a device of this sort on his office desk, and while it is fine for letting a group

listen to what is being said, the person doing the talking has to speak up, and real close to the phone, in order to be heard.

The all-in-one unit, where the phone sits on the combination amplifier/pickup/speaker, has one bad feature. The party at the other end can usually hear himself over the speaker, and the slight delay creates a "bottom-of-the-barrel" echo that is disturbing. Also, be very, very careful. Make sure that you tell people at the other end that you are amplifying the conversation—they might just come out with language that will make you jump in embarrassment.



Courtesy: Radio Shack

#### PARTS LIST

##### TRANSISTORS:

Q1, 2—2N46

Q3—2N255A

##### CAPACITORS:

C1, 2—.1 mfd

C3—100 mfd

##### RESISTORS:

R1—5K pot

R2, 4—1 meg

R3—6.2K

R5—56K

##### BATTERY:

B1—9v

##### COIL:

L1—see text

##### TRANSFORMER:

T1—Match Q3 output to speaker

## Amplifier/Oscillator

This circuit is a simple, straightforward two-stage amplifier—that is, if you eliminate the circuitry connected from the collector of Q2 to the base of Q1. In the amplifier mode, a signal is applied to the base of transistor Q1. The output from the first stage collector is directly coupled to the base of Q2, and from Q2's collector through output transformer T1 to the loudspeaker. As you know, when you couple the output of an amplifier back to its input, feedback will occur, hence the ear-splitting howl when a microphone is placed in front of a PA loudspeaker system. Feedback is deliberately introduced in this unit by coupling the output signal back to the input through capacitor C1. The key serves only to remove the coupling, and therefore the feedback.

This circuit has numerous applications. Obviously, the first thought that will occur is in a code practice oscillator. However, if the key (which is the actuating device) is replaced with a heat sensor, the unit then becomes a fire alarm. Use a humidity detector instead, and you have a rain alarm that will tell you when to close the windows.

To use this circuit as an amplifier, simply remove the components (key and capacitor) from the base of Q1 to the collector of Q2. These parts of the circuit provide a feedback loop. Without them, the unit functions as an amplifier for any high-level source, such as a crystal or ceramic microphone, a crystal or ceramic phono cartridge, or a tuner. We must hasten to point out that, while an amplifier such as this is more than adequate for the purposes to which it was designed, it does have limitations. A two-transistor amplifier is still a two-transistor amplifier, so do not expect high fidelity quality. We make this point only because an over-enthusiastic friend, noting the simplicity of the circuit, immediately proceeded to build a pair of them and wire them as a hi-fi stereo amplifier. If you connect a ceramic or crystal cartridge to

the inputs and a pair of speakers to the outputs, sure you're going to hear stereo. Stereo? Yes! High fidelity? No! As a code practice oscillator, the forced feedback works real well, for the tone is a pleasant one.

### PARTS LIST

#### TRANSISTORS:

Q1—2N104

Q2—2N408

#### CAPACITOR:

C1—.01 mfd

#### RESISTORS:

R1—500 ohms

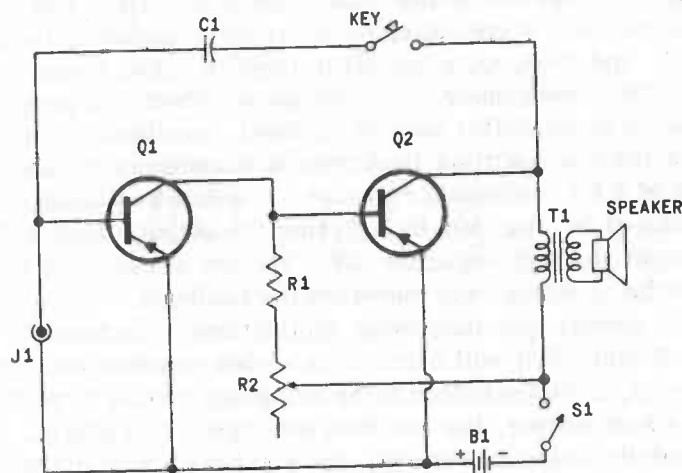
R2—10K pot

#### BATTERY:

B1—6v

#### TRANSFORMER:

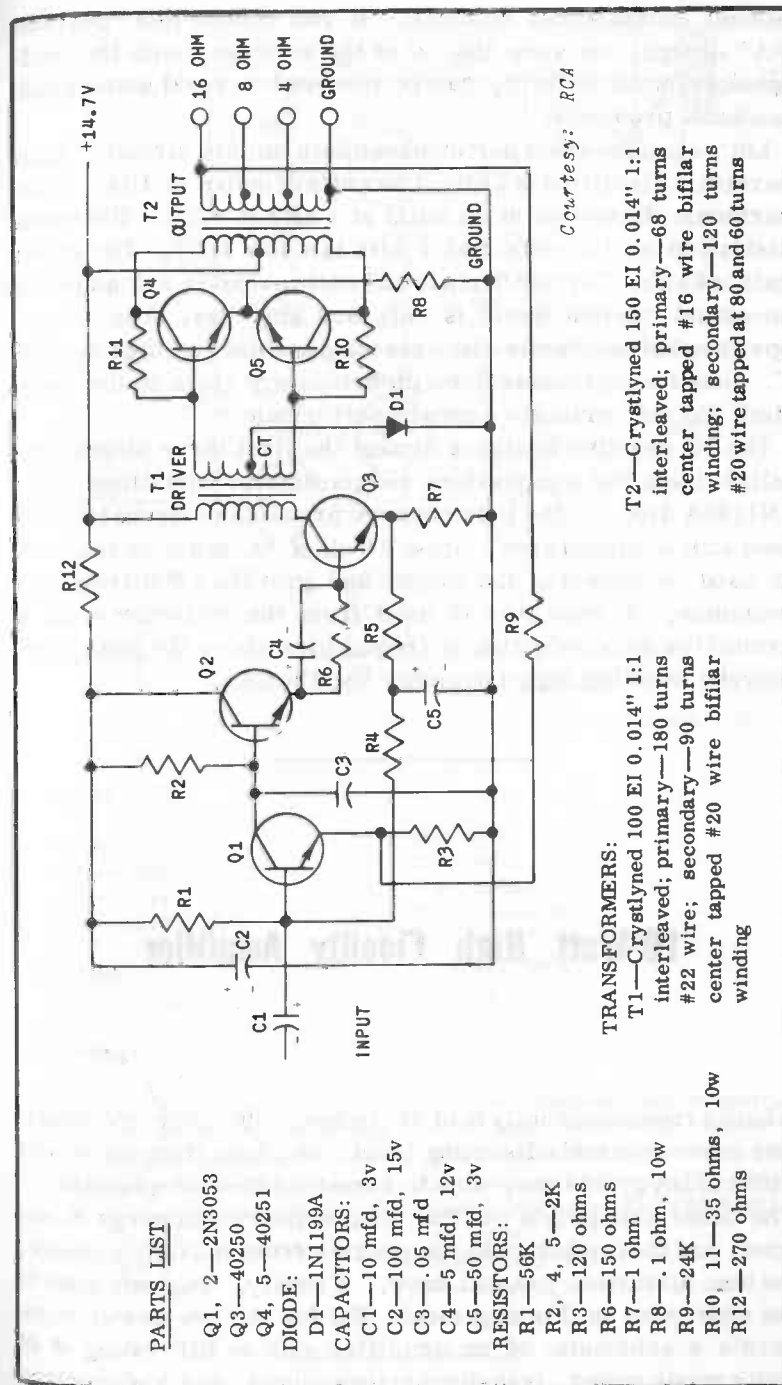
T1—output to match Q2 to speaker



Courtesy: Radio Shack

## 50-Watt PA Amplifier

This unit makes an ideal bull-horn for use in a boat or an airplane. Power output is in the order of 50 watts, more than sufficient. If the unit is fitted with a battery supply, it makes a nice portable PA system that will fit easily (with the bat-



Courtesy: RCA

T2—Crystlyned 150 EI 0.014" 1:1 interleaved; primary—68 turns center tapped #16 wire bifilar winding; secondary—120 turns #20 wire tapped at 80 and 60 turns

#### TRANSFORMERS:

T1—Crystlyned 100 EI 0.014" 1:1 interleaved; primary—180 turns #22 wire; secondary—90 turns center tapped #20 wire bifilar winding

#### PARTS LIST

Q1, 2—2N3053

Q3—40250

Q4, 5—40251

#### DIODE:

D1—1N1199A

#### CAPACITORS:

C1—10 mfd, 3v

C2—100 mfd, 15v

C3—.05 mfd

C4—5 mfd, 12v

C5—50 mfd, 3v

#### RESISTORS:

R1—56K

R2, 4, 5—2K

R3—120 ohms

R6—150 ohms

R7—1 ohm

R8—.1 ohm, 10w

R9—24K

R10, 11—35 ohms, 10w

R12—270 ohms



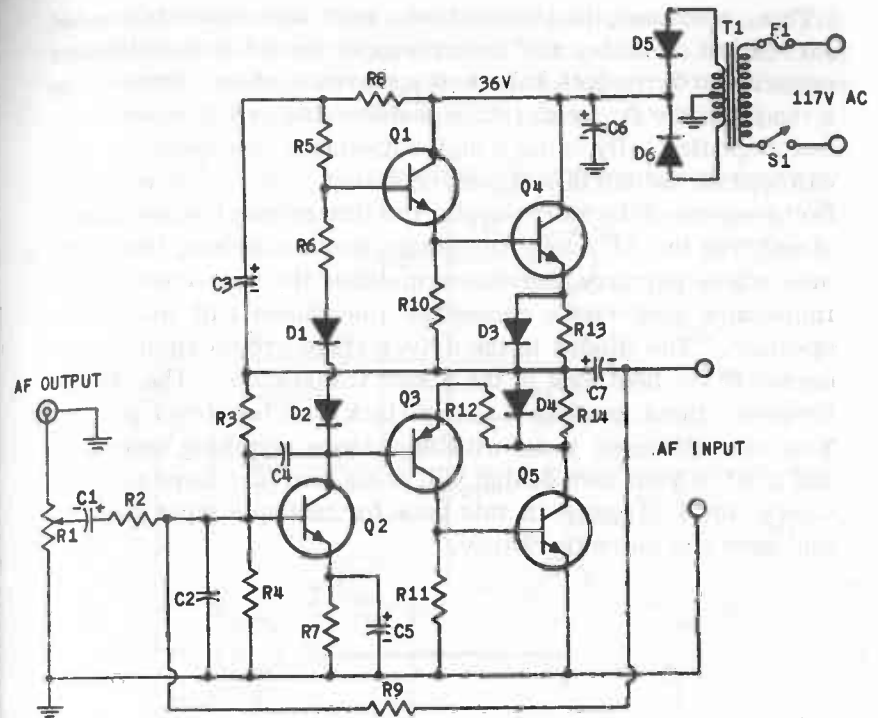
teries) into a small suitcase. If you choose this "portable PA" design, be sure the lid of the suitcase, with the loud-speaker mounted in it, can be removed to avoid some small feedback problems!

Let's examine some performance data on this circuit. Total harmonic distortion at 1 kHz at 50 watts of output is 10%. Total harmonic distortion at 40 watts at 1 kHz is 4.0%. Harmonic distortion at 10 watts and 1 kHz is a low 1.5%. The power gain is 63 db. Current drain for 50 watts output is 8.1 amperes; no-output current drain is only 3.0 amperes. The circuit operates satisfactorily with case temperatures as high as 125° C. Substituting transistors with betas very close to the lower limit did not seriously degrade performance.

The DC negative feedback around the first three stages stabilizes them for temperature and parameter variations. The 1N1199A diode in the bias network provides compensation for heat sink temperatures. About 15 db of AC negative feedback is used to linearize the output and provide a flat frequency response. A capacitor is used from the collector of Q1 to ground for gain reduction at frequencies above the pass band, thereby avoiding high-frequency oscillations.

## 10-Watt High Fidelity Amplifier

A battle rages constantly in hi-fi circles. "If I play my amplifier at a comfortable listening level, oh, less than one watt's worth at any given time, why do I need a 120-watt amplifier?" The other side points out that "music peaks can surge at any time, and the further away you operate from maximum power, the less distortion you will have." Frankly, we don't want to get embroiled in this argument. But for the low-power boys, here's a schematic of an amplifier with an IHF rating of 20 watts music power, transformerless output, and high quality.



Courtesy: RCA

### PARTS LIST

#### TRANSISTORS:

Q1—40314  
Q2—40317  
Q3—40319  
Q4, 5—40310

#### DIODES:

D1, 2—1N3754  
D3, 4, 5, 6—1N3193

#### CAPACITORS:

C1—50 mfd, electrolytic, 6v  
C2—180 pfd, ceramic  
C3—50 mfd, electrolytic, 25v  
C4—68 pfd, ceramic  
C5—100 mfd, electrolytic, 6v  
C6—1000 mfd, electrolytic, 50v  
C7—50 mfd

#### RESISTORS:

R1—10K pot

R2—3.3K  
R3—47K  
R4—5.6K  
R5, 12—4.7K  
R6, 10, 11—220 ohms  
R7—270 ohms  
R8—1K  
R9—0.1 meg  
R13, 14—1 ohm, 1w

#### TRANSFORMER:

T1—power transformer; primary, 117v rms; secondary, center-tapped, 28v rms from center tap to each end at 500 ma DC; Tri-wec Transformer Co. #RCA-111, or equiv.

#### MISCELLANEOUS:

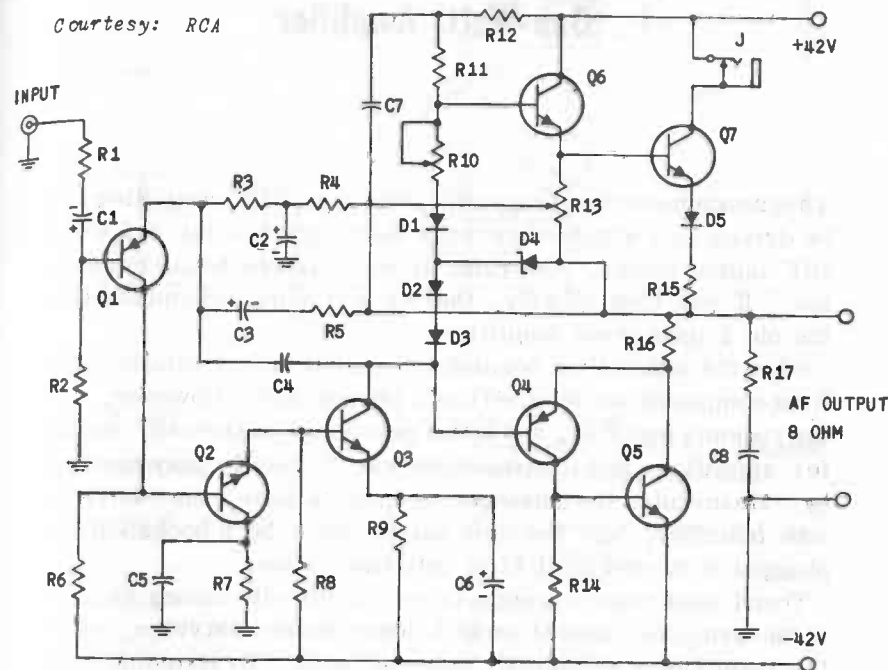
F1—fuse, 1 amp

This, of course, is a monophonic unit, and a pair is needed for stereo. As is, the power supply should have sufficient capacity to drive both halves of a stereo system. Simply run a tap from the B point (at the positive side of C6) to the second amplifier. By using a high-impedance loudspeaker, you can operate the unit in a transformerless fashion. If you prefer to use one of the more popular low-impedance loudspeakers, simply run the AF output terminals into a matching transformer whose primary impedance matches the transistor output impedance and whose secondary impedance will match the speaker. The diodes in the driver stage are thermally connected to the heat sink of the output transistors. The audio-frequency input consists of a single jack for a low-level source. You can add input jacks with impedance matching networks, and a bit of your own design will come into play here as well. Check other circuits in this book for multiple input circuits that give you more flexibility.

## 70-Watt Class AB Amplifier

In this class AB circuit, quality is somewhat sacrificed for quantity. In electronics you don't get something for nothing, either. Here, you surrender a small amount of fidelity, and in return get a lot of amplification for the same given input parameters. But don't get the idea that this circuit is in any way lacking! Consider what happens to sound when it's put through a telephone, for example. Telephone quality is pretty bad, from a hi-fi viewpoint, but it's totally intelligible, isn't it? The quality of this amplifier will match that of any public address system, and it certainly operates with good efficiency. But don't plan to build two of these units into a stereo amplifier and expect fantastic frequency response characteristics. You just won't get them. Jack J in the 40411 circuit

is used to connect a meter for bias adjustment. Set potentiometer R10 for a meter reading of 20 ma with no loudspeaker connected and no drive applied to the input. D1 and D2 are thermally connected to the output transistors' heat sink.



### PARTS LIST

#### TRANSISTORS:

Q1—40406  
Q2—40407  
Q3—40408  
Q4—40410  
Q5, 7—40411  
Q6—40409

#### DIODES:

D1, 2, 3—1N3754  
D4—1N1519 zener  
D5—1N1612R

#### CAPACITORS:

C1—5 mfd, 6v  
C2—1000 mfd, 3v  
C3—2 mfd, 6v  
C4—100 pfd  
C5—.01 mfd  
C6—250 mfd, 6v

C7—100 mfd, 50v  
C8—.1 mfd

#### RESISTORS:

R1—82K  
R2—18K  
R3—180 ohms  
R4, 7—10K  
R5—33K  
R6—100K  
R8—4.7K  
R9—270 ohms  
R10—250 ohm pot  
R11—5.6K  
R12—3.9K  
R13—100 ohm pot  
R14—100 ohms  
R15—.33 ohms, 10w  
R16—.27 ohms, 10w  
R17—20 ohms, 5w

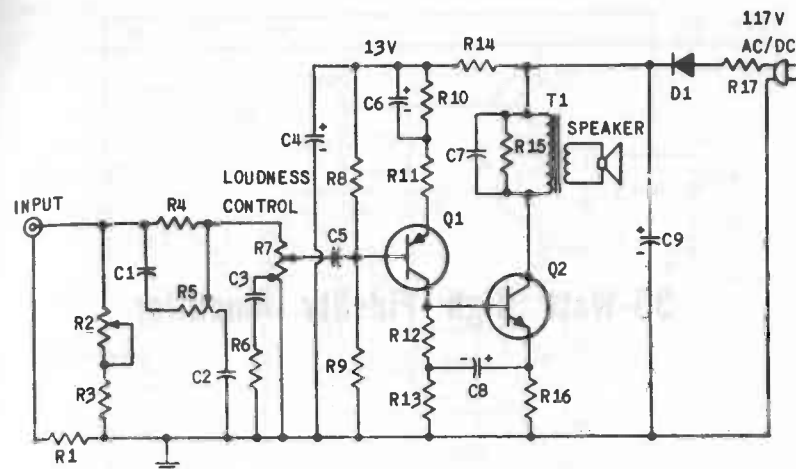
## One-Watt Amplifier

This inexpensive two-transistor one-watt (RMS) amplifier can be driven by a standard ceramic cartridge to a full 2.5 watts IHF music power. Operates from standard house current, too. If you look closely, there's a striking resemblance to the old 2-tube phono amplifier.

When the author first became interested in high fidelity, the first component we obtained was a phonograph. However, being recently married, and with a new house to furnish, money for amplifiers and loudspeakers wasn't exactly easy to come by. Meanwhile, the phono got set up in its base, the cartridge was installed, and the unit put in place on a bookshelf and plugged in to wait until Lord only knew when.

Then I came home one night to see friend wife sitting in front of the turntable, her ear cocked closely to the cartridge, while the turntable was merrily spinning away. By listening very closely, she was able to hear the stylus scratch in the groove of the record and make out some of the music. That's all we needed. That very night we built an amplifier such as this one, except that it used a couple of tubes. No cabinet, nothing fancy. The tubes were a 35Z5 and a 50L6, with a line-cord dropping resistor to take up the load. A four-inch loudspeaker in a cardboard box completed the installation. The amplifier had a volume control and a tone control, and that was it. To my wife's delight, the sound "filled" the room, and while the fidelity was more than lacking, at least she could hear the records.

Now our stereo system boasts over 75 different knobs and controls, counting the two tape decks, and the lady of the house has learned how to use the system. But she still talks fondly of her old two-knob amplifier, and frankly, while our sound is indisputably better, it was our first, and I kind of miss it too.



Courtesy: RCA

### PARTS LIST

#### TRANSISTORS:

Q1—40263  
Q2—40425 or 40424

#### DIODE:

D1—40265

#### CAPACITORS:

C1, 2—1200 pfd, ceramic disc  
C3—0.005 mfd, ceramic disc  
C4—80 mfd, electrolytic, 25v  
C5—0.1 mfd, ceramic disc  
C6, 8—25 mfd, electrolytic, 6v  
C7—0.01 mfd, ceramic disc  
C9—80 mfd, electrolytic, 150v

#### RESISTORS:

R1—56K  
R2—base control potentiometer, 3 meg, audio taper  
R3—68K

R4—0.33 meg  
R5—treble control, potentiometer, 1 meg, audio taper  
R6—10K  
R7—2 meg pot, tapped at 1 meg, linear taper  
R8, 14—18K  
R9—33K  
R10, 15—1K  
R11—68 ohms  
R12—470 ohms  
R13—820 ohms  
R16—120 ohms  
R17—250 ohms

#### TRANSFORMER:

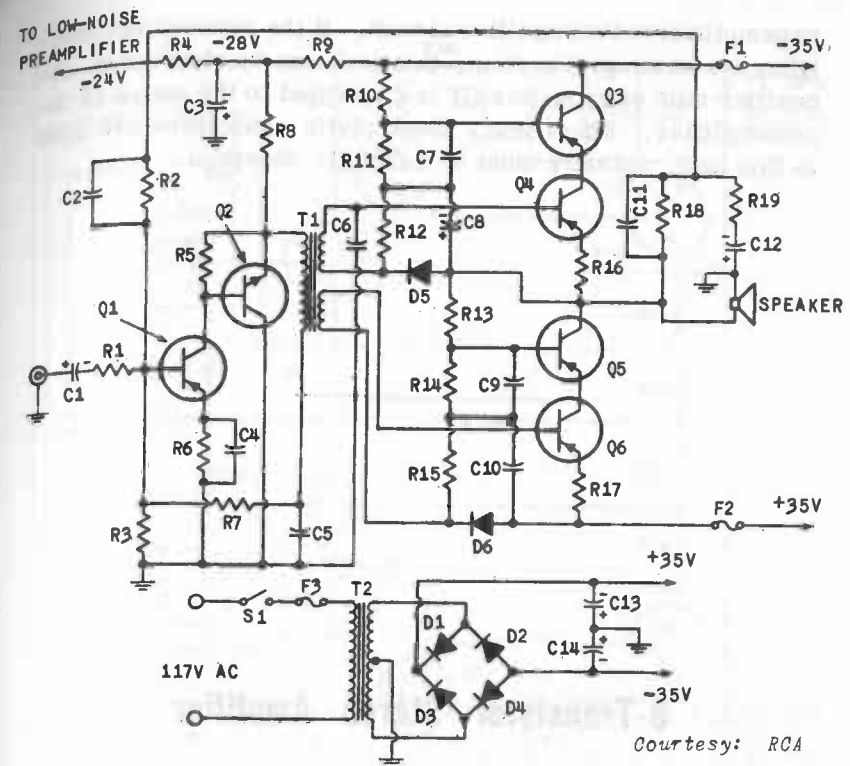
T1—audio output transformer; matches collector load impedance of 2.5K to speaker voice-coil impedance of 3.2 ohms; Freed #RCA-8, Triad #S-12X, or equiv.

## 35-Watt High Fidelity Amplifier

This excellent power amplifier is the type used in "top of the line" high fidelity systems. It features exceedingly low hum and noise level, good transient response, and excellent stability. For stereo, two amplifier circuits are needed, of course. The power transformer has the ability to handle the doubled load, so one power supply is adequate for both channels. The amplifier output is only as good as its input, so a good quality preamplifier is recommended with this circuit.

One of the interesting features of this amplifier is the transformerless output. In circuits of this type the output transistors operate with only a high-impedance loudspeaker as the load. If they are operated with no speakers attached, the final transistors will "run away" and destroy themselves. Therefore, a loudspeaker must be connected before the amplifier is turned on. Circuit protection is afforded by three fuses. F3 serves as a primary fuse, while F1 and F2 protect the positive and negative legs of the supply secondaries.

You will observe that the power supply also provides 24 volts negative for the low-noise preamplifier. This voltage is derived from the -35 volt supply and is dropped through L-section filter C3 and R4. If the preamplifier is self-powered, these circuit components can be eliminated, but be exceedingly careful to polarize the voltages so that short-circuiting does not occur when the units are interconnected. The jack in the base circuit of the input transistor is used for coupling the



Courtesy: RCA

### PARTS LIST

#### TRANSISTORS:

- Q1—40329
- Q2—2N3241
- Q3, 5—40051
- Q4, 6—2N2147

#### DIODES:

- D1, 2, 3, 4—40267
- D5, 6—1N2326

#### CAPACITORS:

- C1—5 mfd, electrolytic, 3v
- C2, 11—39 pfd, ceramic disc
- C3, 13, 14—2500 mfd, electrolytic, 35v
- C4—200 mfd, electrolytic, 3v
- C5—250 mfd, electrolytic, 15v
- C6—0.001 mfd, ceramic disc
- C7, 9—0.2 mfd, ceramic disc
- C8, 10—100 mfd, electrolytic, 15v
- C12—10 mfd, electrolytic, 3v

#### RESISTORS:

- R1—1.5K
- R2, 3—22K
- R4, 5—270 ohms
- R6, 19—1K
- R7—56K

- R8—470 ohms, 1w
- R9—82 ohms, 1w
- R10, 13—220 ohms, 2w
- R11, 14—68 ohms, 1w
- R12, 15—150 ohms, 1w
- R16, 17—0.33 ohm, 1w
- R18—33K

#### TRANSFORMERS:

T1—consists of 5 penta-filar-wound coils of 110 turns each; wound from #28 heavy Formvar insulated wire on grain-oriented silicon-steel, 1/2-inch EI square stack; interleaved, with no air gap; 3 windings are connected in series to form primary; other two windings form the split secondary; secondary DC resistance, 2 ohms per secondary winding; primary DC resistance, 6 ohms

T2—power transformer; Better Coil and Transformer Co. #99P6, Columbus Process Co. #X8300, or equiv.

#### MISCELLANEOUS:

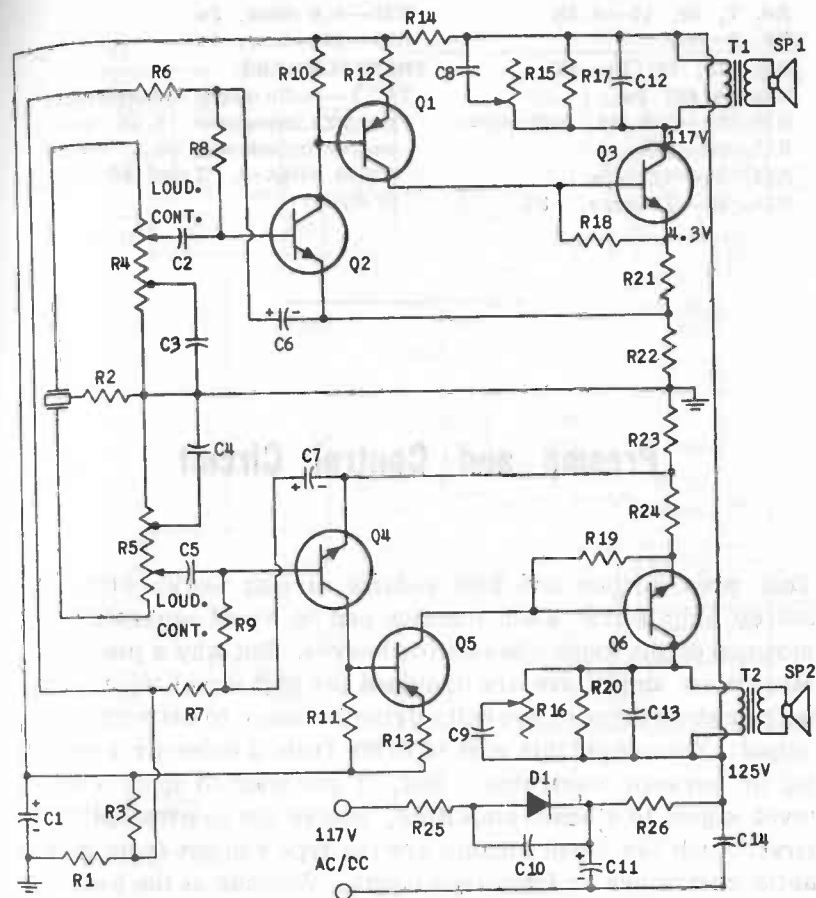
- F1, 2—fuse, 3 amp
- F3—fuse, 2 amp, slobber

preamplifier to the amplifier circuit. If the preamp and amplifier are an integral system, this jack can be eliminated; the positive side of capacitor C1 is connected to the output of the preamplifier. Since many electrolytic capacitors are used in this unit, polarity must be carefully observed.

## 6-Transistor Stereo Amplifier

Capable of 2 watts output per channel, this 6-transistor stereo amplifier circuit operates directly from the power line with any crystal or magnetic cartridge input. Although the schematic doesn't show it, a switch can be inserted in the power line ahead of R25 and attached to either the loudness or tone controls. Since each amplifier circuit requires a separate loudness and tone control, they may be ganged to reduce the number of operating controls.

Two additional resistors in the hot side of R4 and R5 will help keep volume down, in case the amplifier is being used by youngsters. Values can best be determined by trial and error. While not exactly in the hi fi category, this circuit provides quite acceptable quality for many low-cost phono applications.



Courtesy: RCA

### PARTS LIST

#### TRANSISTORS:

- Q1, 5—40359
- Q2, 4—40399
- Q3, 6—40424

#### DIODE:

- D1—40265

#### CAPACITORS:

- C1—100 mfd, electrolytic, 15v
- C2, 5—0.01 mfd, ceramic disc
- C3, 4—0.0022 mfd, ceramic disc
- C6, 7—5 mfd, electrolytic, 3v
- C8, 9—0.1 mfd, ceramic disc, 1200v

- C10—0.047 mfd, ceramic disc, 400v
- C11, 14—100 mfd, electrolytic, 15v (dual electrolytic capacitor may be used)
- C12, 13—0.005 mfd, ceramic disc

#### RESISTORS:

- R1—82 ohms,  $\pm 5\%$
- R2—68K (This resistor may be replaced by 0.047-mfd, 400v capacitor)
- R3—1K,  $\pm 5\%$
- R4, 5—5 meg pot, tapped at 1.5 meg, linear taper

Cont.

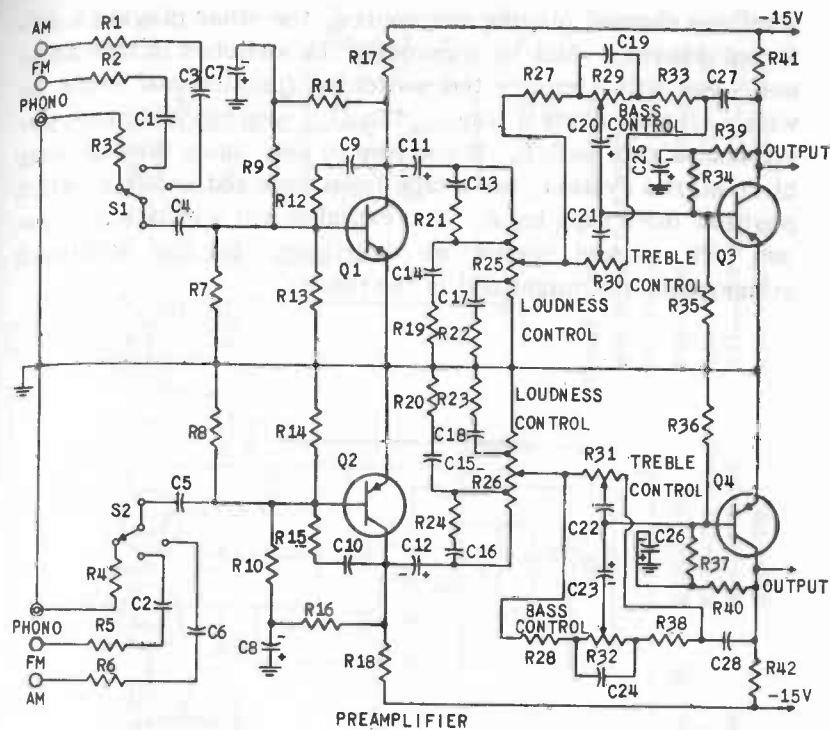
R6, 7, 10, 11—8.2K  
 R8, 9—47K  
 R12, 13, 18, 19—1K  
 R14—6.8K, 2w  
 R15, 16—50K pot, audio taper  
 R17, 20—18K  
 R21, 24—82 ohms  
 R22, 23—11 ohms,  $\pm 5\%$

R25—6.8 ohms, 2w  
 R26—200 ohms, 4w  
**TRANSFORMERS:**  
 T1, 2—audio output transformer;  
 primary impedance, 2.5K; sec-  
 ondary impedance, 3.2 ohms;  
 Freed #R6A-8, Triad #S-12X,  
 or equiv.

## Preamp and Control Circuit

This preamplifier and tone control circuit works with any stereo amplifier. Each function can be wired separately or mounted on the same chassis (or board). But why a preamp? Most basic amplifiers are designed for high-level input, requiring about three to five volts drive in order to deliver rated output. You can get this sort of drive from a tuner or a crystal or ceramic cartridge. But, if you want to apply a low-level signal to a basic amplifier, you've got to preamplify it first. Such low-level signals are the type you get from magnetic cartridges or from tape heads. Another of the preamplifier's functions is to provide the convenience of multiple input connections so you needn't be constantly plugging and unplugging input lead wires. A preamplifier also provides tone, level, and balance controls needed for high fidelity amplification.

This four-transistor circuit performs all of these functions. You can, with a little thought, modify the circuit in some ways to improve the versatility of the unit. For example, the author frequently likes to tape record directly off the air. If you add another jack to each channel, and connect it through a .01-mfd capacitor to each output terminal, the new jack can be connected to a tape recorder input (use the LINE input) and you can record anything being played through the amplifier! S1 and S2 can be a 2-deck 3-position switch, with one deck for each channel. It isn't very likely that you will



Courtesy: RCA

### PARTS LIST

#### TRANSISTORS:

Q1, 2—40395  
 Q3, 4—40263

#### CAPACITORS:

C1, 2—5600 pfd  
 C3, 6—6800 pfd  
 C4, 5, 19, 24—0.047 mfd  
 C7, 8, 25, 26—2 mfd, 12v  
 C9, 10—3300 pfd  
 C11, 12—10 mfd, 15v  
 C13, 16, 21, 22—0.01 mfd  
 C14, 15, 17, 18—0.22 mfd  
 C20, 23—10 mfd, 6v  
 C27, 28—0.15 mfd

#### RESISTORS:

R1, 6—47K

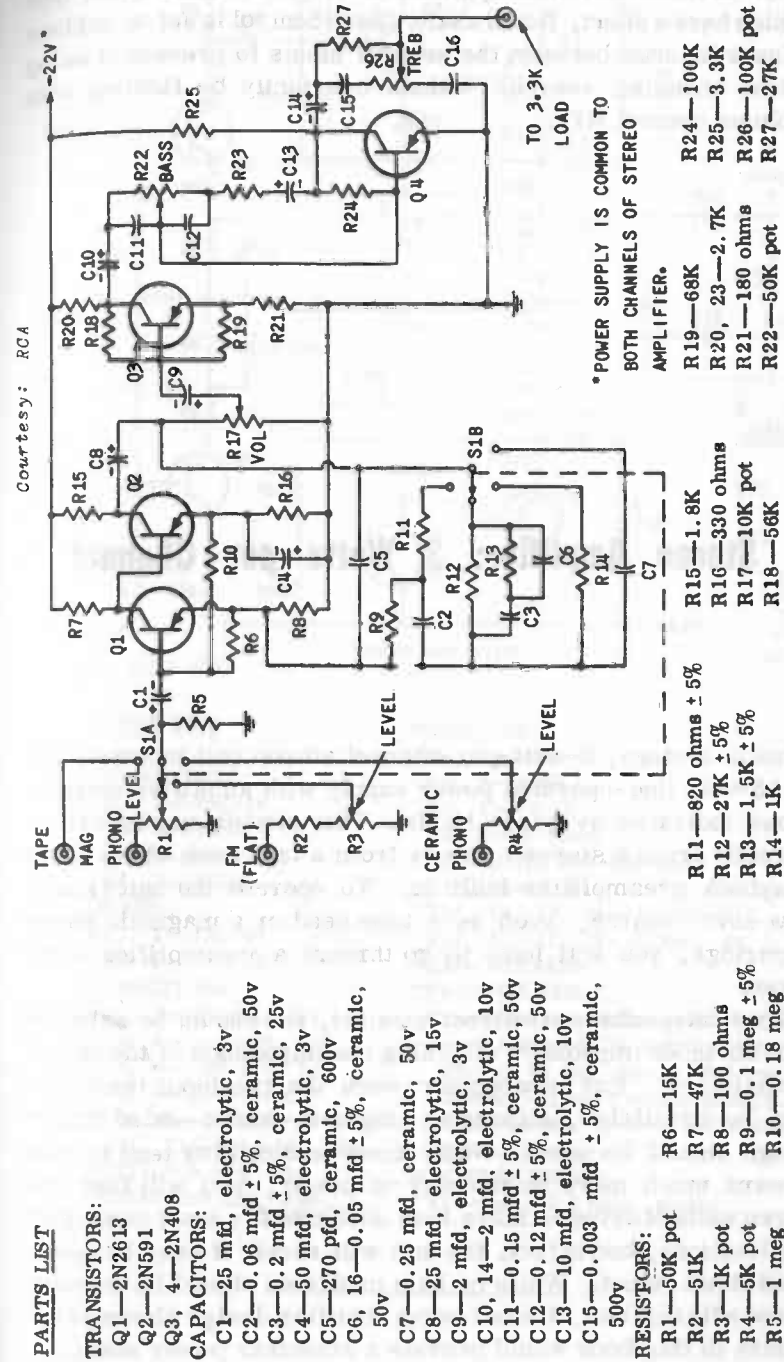
R2, 5—56K  
 R3, 4—120K  
 R7, 8—1 meg  
 R9, 10, 11, 16, 34, 37, 39, 40  
 —220K  
 R12, 15—100K  
 R13, 14, 17, 18, 35, 36, 41, 42  
 —10K  
 R19, 20, 22, 23—1.5K  
 R21, 24—3.3K  
 R25, 26—150K pot, linear; tap-  
 ped at 5 and 10K  
 R27, 28, 33, 38—5.6K  
 R29, 32—50K pot, linear  
 R30, 31—25K pot

want one channel playing one source, the other playing a different source. And by combining the switches in this manner, you will simplify the switching function and come up with a cleaner control panel. Finally, you can add more positions to this switch. If you like to play tapes through your hi-fi/stereo system, add a tape input jack and another switch position for a tape input. You can also add a switch position and jack marked "extra" or "auxiliary" for any additional components you might add in the future.

## High Fidelity Preamp

Here's an excellent preamplifier and control center for use with any amplifier circuit. A wide assortment of inputs makes this a flexible addition to any stereo system. Since this preamplifier is monophonic, a pair is needed for stereo, of course. The unit requires a supply voltage of -22 volts, and its output connects to any power amplifier with a 3300-ohm input. RCA-type phono plugs are recommended at the input terminals. The outer shields should be grounded to the chassis. If you go the stereo mode, you can obtain dual-input jacks (one for each channel) on a single phenolic insulator.

Three potentiometers, R1, R3, and R4, are marked "level." Further along in the schematic, you will find R17, marked "volume." R1, R3, and R4 level potentiometers are mounted on the rear apron of the chassis, and in our experience the

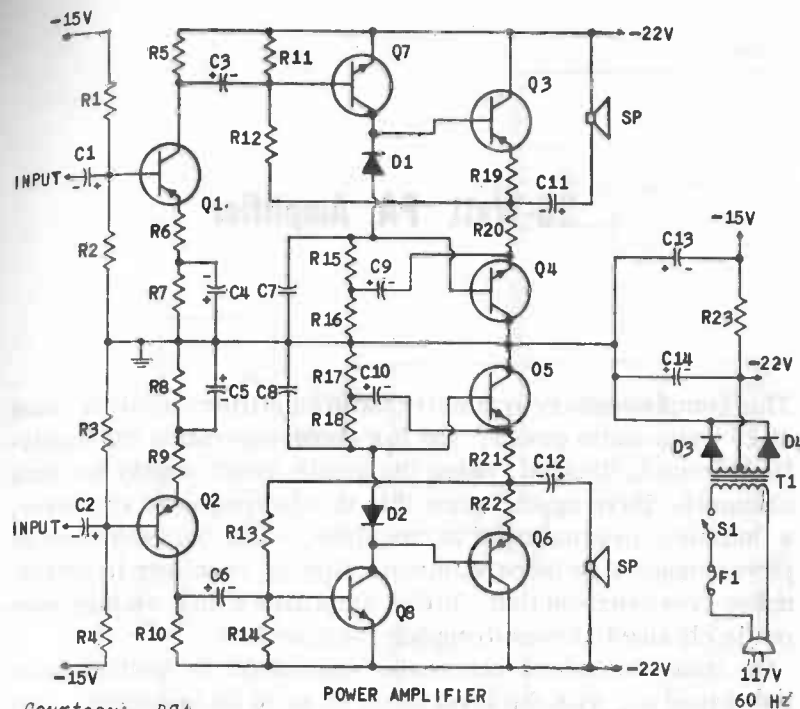


best controls for this application are the finger-adjust type which have a short, fluted shaft. Each control is set to achieve closer balance between the several inputs to prevent blasting when changing sources without constantly be fiddling with volume control R17.

## Stereo Amplifier: 3 Watts per Channel

This is 5-stage, 3-watt-per-channel stereo unit incorporates a 15-volt line-operated power supply with amplifier connections indicated by arrow heads. This circuit may be driven directly from a stereo tuner or from a tape deck which has a playback preamplifier built in. To operate the unit from a low-level source, such as a tape head or a magnetic phono cartridge, you will have to go through a preamplifier stage first.

The loudspeakers are direct-coupled, and should be selected for an input impedance matching the impedance of the output transistors. For monophonic work the two input terminals can be paralleled, although a single-to-double-ended driver stage should be used. While many audiophiles tend to lean toward much more in the way of power, you will find that three watts of drive is more than adequate for most consumer applications, and in fact, the unit will rarely if ever be operated at full output. While no hum problems should be encountered with this unit, the full-wave rectifier design shown elsewhere in this book would provide a smoother power source.



Courtesy: RCA

### PARTS LIST

#### TRANSISTORS:

- Q1, 2—2N2614
- Q3, 6—40253
- Q4, 5—40457
- Q7, 8—40398

#### DIODES:

- D1, 2—1N3754
- D3, 4—40266

#### CAPACITORS:

- C1, 2—10 mfd, 15v
- C3, 6—100 mfd, 15v
- C4, 5—500 mfd, 3v
- C7, 8—0.056 mfd
- C9, 10—50 mfd, 6v
- C11, 12—500 mfd, 25v
- C13—500 mfd, 15v
- C14—2000 mfd, 25v

#### RESISTORS:

- R1, 4—56K
- R2, 3—8.2K
- R5, 10—2.2K
- R6, 8—27 ohms
- R7, 9, 11, 14—220 ohms
- R12, 13—3.3K
- R15, 16, 17, 18—180 ohms
- R19, 20, 21, 22—1 ohm, 1w
- R23—330 ohms

#### TRANSFORMER:

- T1—power transformer; full-wave center-tapped; DC output voltage 22v at 95 ma, 20v at 285 ma; Better Coil and Transformer Co. #EX4744 P, C-P Electronics #8970, or equiv.

#### MISCELLANEOUS:

- F1—fuse, 0.5 amp, sloblo

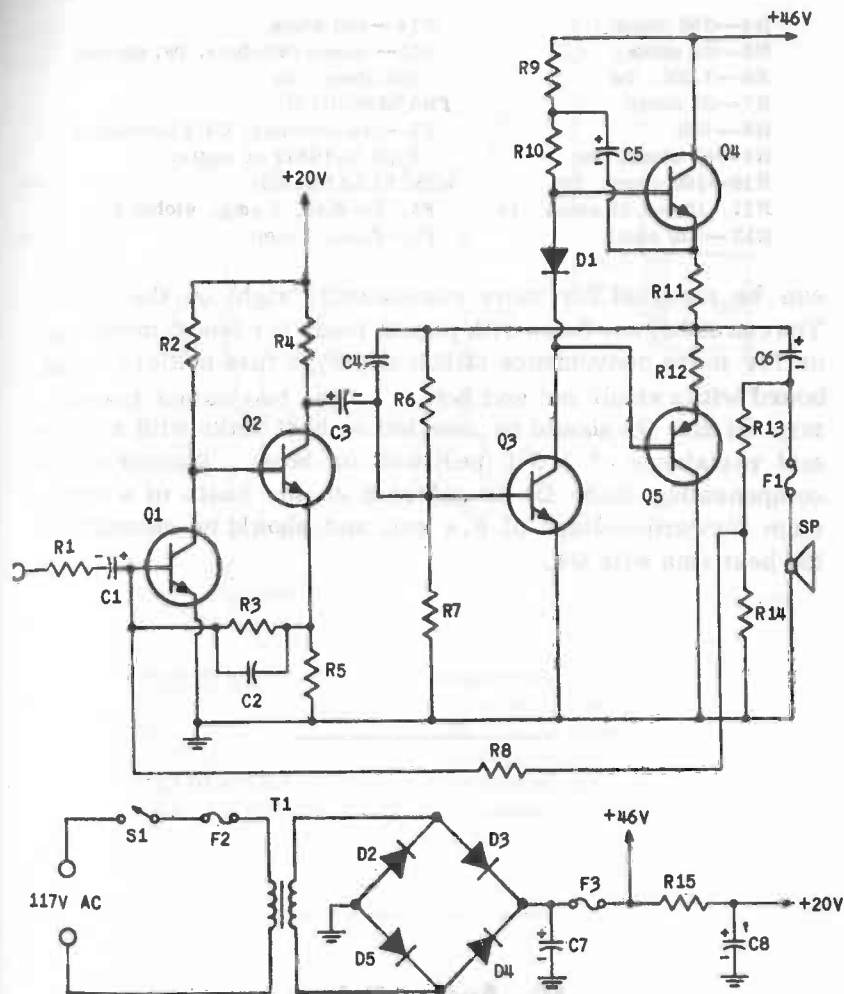


## 25-Watt PA Amplifier

This complementary symmetry audio amplifier circuit is rated at 25 watts audio power, and for stereo operation the amplifier circuit is doubled, using the single power supply for both channels. Here again, since this is a basic power amplifier, a suitable preamplifier is required. The balanced bridge power supply also helps eliminate ripple, resulting in better, noise-free reproduction. In this amplifier a dual voltage output is obtained across dropping resistor R15.

On many occasions electronic equipment is inadvertently left turned on, with the level down so as to be inaudible. The equipment continues to sit there and cook, and the problem, while not as severe in the case of solid-state circuitry, is nonetheless not exactly beneficial to the unit itself. To get around this, it seems expedient to add a simple neon pilot lamp across the primary of T1, and mount it in such a way that the lamp is plainly visible. Make sure that you use a dropping resistor in series with the lamp—about 220K, 1/2 watt should do the job. There also are neon pilot lamps available with a dropping resistor built into the lamp holder and an attractive red jewel that provides ample light with an NE-2H bulb.

This amplifier can be used in a number of applications, provided there is suitable drive from a preamplifier. Typical applications would include high fidelity, of course, but it also can be used in an electronic organ, as a playback amplifier for a tape deck, and the 25 watts is sufficient for use as a musical instrument amplifier. Three fuses offer more than sufficient protection in this unit: The primary fuse, between the switch and the transformer, should be a chassis-mounted type, accessible from the back of the chassis. If the circuit is constructed on etched-circuit boards, the other two fuses



Courtesy: RCA

### PARTS LIST

#### TRANSISTORS:

Q1, 2—40398  
Q3—40544  
Q4—40466  
Q5—2N2147

#### DIODES:

D1—1N3754  
D2, 3, 4, 5—40266

#### CAPACITORS:

C1—5 mfd, 15v

C2—500 pfd  
C3—250 mfd, 50v  
C4—1000 pfd  
C5—250 mfd, 15v  
C6—1000 mfd, 50v  
C7—3500 mfd, 50v  
C8—1000 mfd, 25v

#### RESISTORS:

R1—2.2K  
R2—12K  
R3—100K

Cont.

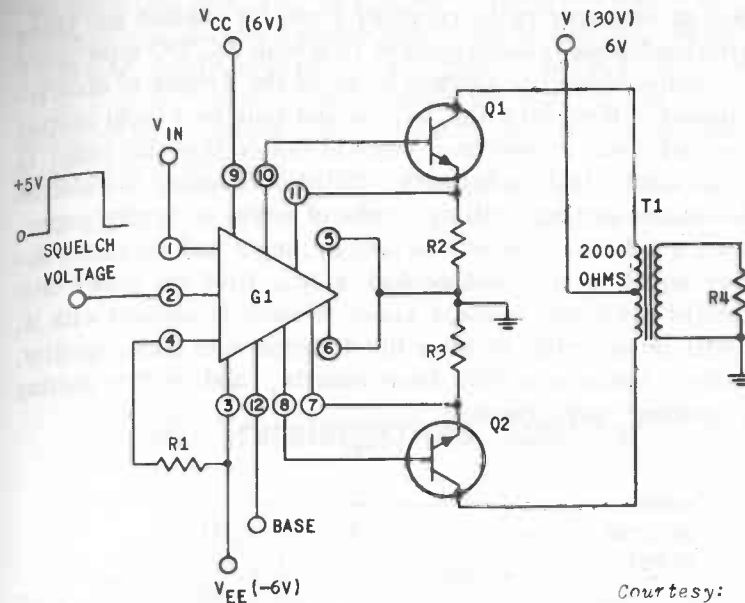
R4—390 ohms  
 R5—68 ohms  
 R6—1.2K, 1w  
 R7—33 ohms  
 R8—75K  
 R9—82 ohms, 2w  
 R10—100 ohms, 2w  
 R11, 12—0.39 ohms, 1w  
 R13—130 ohms

R14—560 ohms  
 R15—mono: 680 ohms, 1w; stereo:  
 330 ohms, 2w  
**TRANSFORMER:**  
 T1—transformer: CP Electronics  
 Type X-10307 or equiv.  
**MISCELLANEOUS:**  
 F1, 2—fuse, 2 amp, slobber type  
 F3—fuse, 5 amp

can be mounted far more conveniently right on the board. You can either use fuses with pigtail leads for board mounting, or for more convenience attach clip-type fuse holders to the board with a small nut and bolt. The two output transistors Q4 and Q5 should be mounted on heat sinks with a thermal resistance of 1.5°C per watt or less. Temperature-compensating diode D1 is selected on the basis of a maximum forward-voltage of 0.8 volt and should be mounted on the heat sink with Q4.

## IC Audio Driver

If you need an ultra-compact low-power audio amplifier, here is a 300 mw device using an integrated circuit as a driver. Terminal 2 should be grounded, or if a squelch circuit is incorporated in earlier stages, it must be connected to +5 volts. Both driver and amplifier are shown here. The driver, an RCA CA3007 integrated circuit, is used to feed a pair of 2N2102 transistors.



Courtesy: RCA

### PARTS LIST

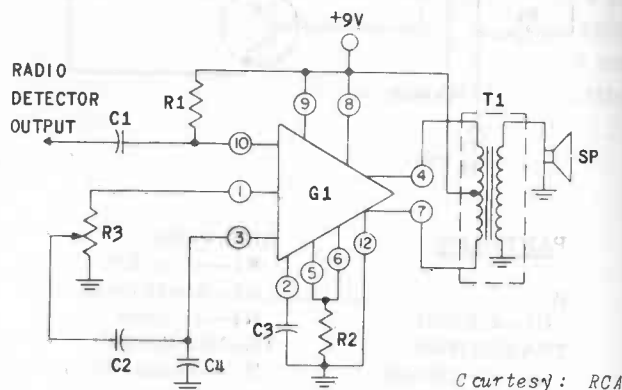
IC:  
 G1—CA3007  
**TRANSISTORS:**  
 Q1, 2—2N2102

**RESISTORS:**  
 R1—6K to 12K  
 R2, 3—18 ohms  
 R4—16 ohms  
**TRANSFORMER:**  
 T1—Stancor TA-10

## 545-Milliwatt IC Amplifier

Input voltage requirement for this circuit is 45 millivolts for full power output. This is a high fidelity circuit, more than adequate as a tape playback amplifier or a phono amplifier operating directly from the cartridge. Before we go into detail regarding an additional and important application for this amplifier, let's consider a small but very enlightening experiment.

Take an ordinary radio receiver from its cabinet and place it so the loudspeaker faces upward (if it's an AC/DC type place it on a non-conductive surface to avoid the danger of electrical shock). Now turn the unit on and tune to a local station so you get clear reception. You will notice that the sound is tinny and totally lacking in depth. Without changing the station or the volume setting, roll up a tube of heavy wrapping paper, forming a column at least two feet in length and an inside diameter equal to the loudspeaker size. Hold the paper tube vertically over the speaker cone, almost in contact with it. You will be startled to hear the difference in sound quality. Suddenly, there are rich bass sounds, and you're getting "big speaker" performance.



Courtesy: RCA

#### PARTS LIST

##### IC:

G1—CA3020

##### CAPACITORS:

C1, 2, 3—1 mfd

C4—.01 mfd

##### RESISTORS:

R1—510K

R2—0.6 ohms

R3—5K pot

##### TRANSFORMER:

T1—Argonne 174 or equiv.

Why? A loudspeaker is a transducer designed to convert electrical energy into audio energy or sound waves. It does this quite well, and did so when it operated exposed and without the paper tube. But a loudspeaker must do more. It must couple the generated sound into the adjoining air. Cabinets, baffles, and larger speaker cones work toward that end. In a small radio we often have to sacrifice the quality of the sound in favor of compactness, and if a transistor has an output impedance of 130 ohms a smart designer is going to use a small loudspeaker with a 130-ohm impedance and save the cost, size, and weight of a matching transformer.

So let's say that you bought one of today's small FM transistor radios and you'd like a better sound quality. Build this integrated circuit amplifier, use a good-sized 3.2-ohm speaker in a good cabinet, and connect the input to the ratio detector output. You can usually pick up the audio at the volume control input terminal.

## IC Transformerless Amplifier

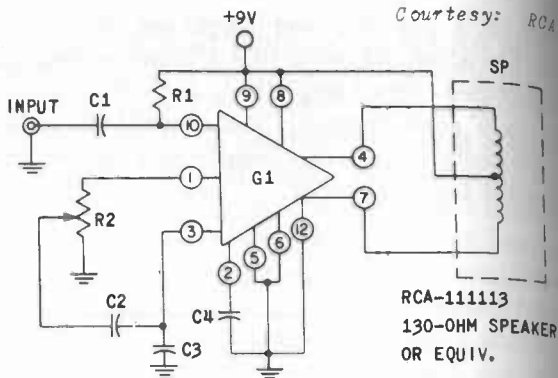
This circuit is ideal for converting an AM or FM tuner into a receiver. A 45 mv drive is required, and no output transformer is needed. Output power is 310 milliwatts, more than sufficient for comfortable listening.

If anybody greeted integrated circuits with delight, it was that vast group of people who make money by writing for the various electronic publications. Here was a brand new device to jump on, a "component" that would change things just as the transistor did! To understand how this worked, you've got to go back a bit. The story really begins with the type 73 triode, an old radio tube with a chunky black base from which the connecting pins emerged. Today, we'd call that base a "plastic." We called it bakelite. In those days there were only two "plastic" materials—a rigid one called bakelite and a semi-flexible one called "beetleware."

So you used the 73 triode to design and build a one-tube receiver, based on a regenerative Hartley oscillator with a variable tickler coil. You wrote an article on how to do it and sold the article to a radio magazine. When the tube manufacturers came out with miniature 7-pin all-glass tubes (no big black bases), you redesigned your little one-tuber and sold the story all over again. By this time things had somewhat improved, and you could even get prewound coils. There was still a bit of confusion in the resistor field, however. The

## PARTS LIST

IC:  
G1—CA3020  
CAPACITORS:  
C1, 4—1 mfd  
C2—.1 mfd  
C3—.01 mfd  
RESISTORS:  
R1—510K  
R2—5K pot



old "body-end-dot" colors were giving way to today's banded types.

Along came the transistor.

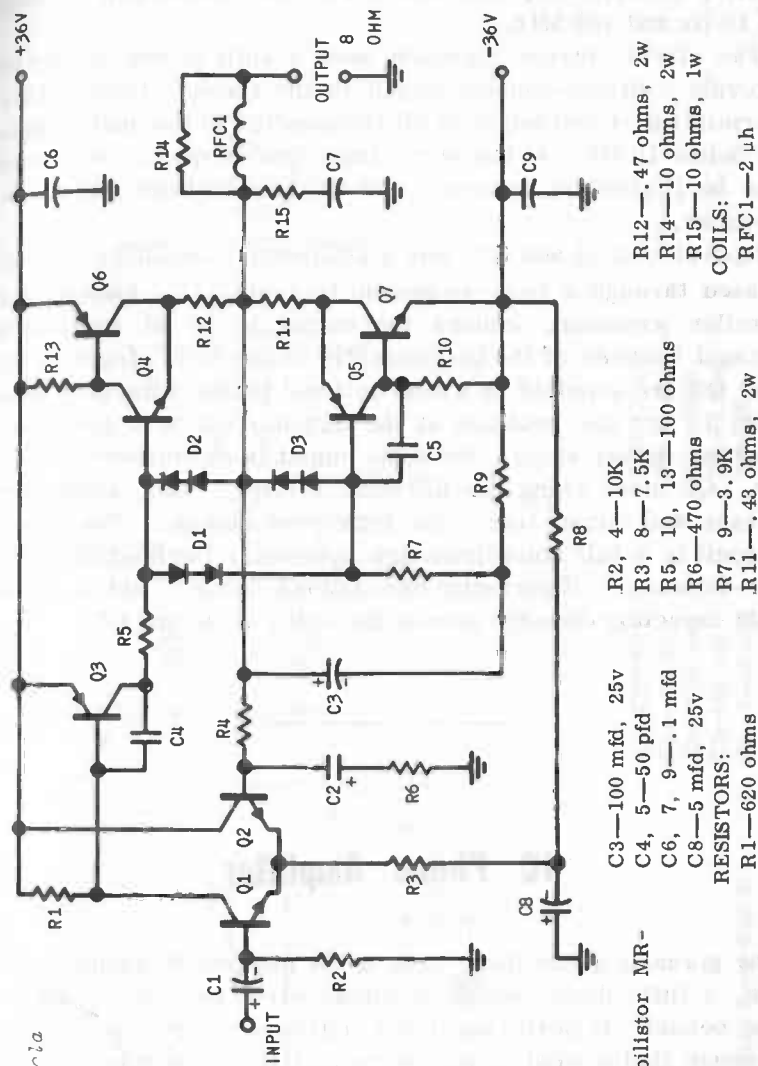
Now we have integrated circuits.

And guess what.

Got an AM or FM tuner? Here is a quick and easy way to get it into operation as a receiver. Quite frankly, you'll find this amplifier a handy device for testing transistor radio amplifier circuits, too. If your receiver suddenly stops working and you know the battery is good, simply connect the amplifier input across the receiver volume control. If the sound starts blaring out the amplifier's loudspeaker, your transistor radio has a defective amplifier.

## 60-Watt PA Amplifier

The specifications of this amplifier speak for themselves: Rated output is 60 watts music power to an 8-ohm load. Sensitivity is 1.0 volt rms into 10K for full rated output. Less than 0.15% intermodulation distortion at full rated output. At



## PARTS LIST

TRANSISTORS:  
Q1, 2—MO8002  
Q3—MM4009  
Q4—MM3006  
Q5—MM4006  
Q6—MJ2941  
Q7—MJ2841  
DIODES:  
D1, 2, 3—dual - stabilistor MR-2361  
CAPACITORS:  
C1—100 mfd, 6v  
C2—50 mfd, 6v

1 kHz, at full power, less than 0.1% THD. Bandwidth is -3db at 10 Hz and 100 kHz.

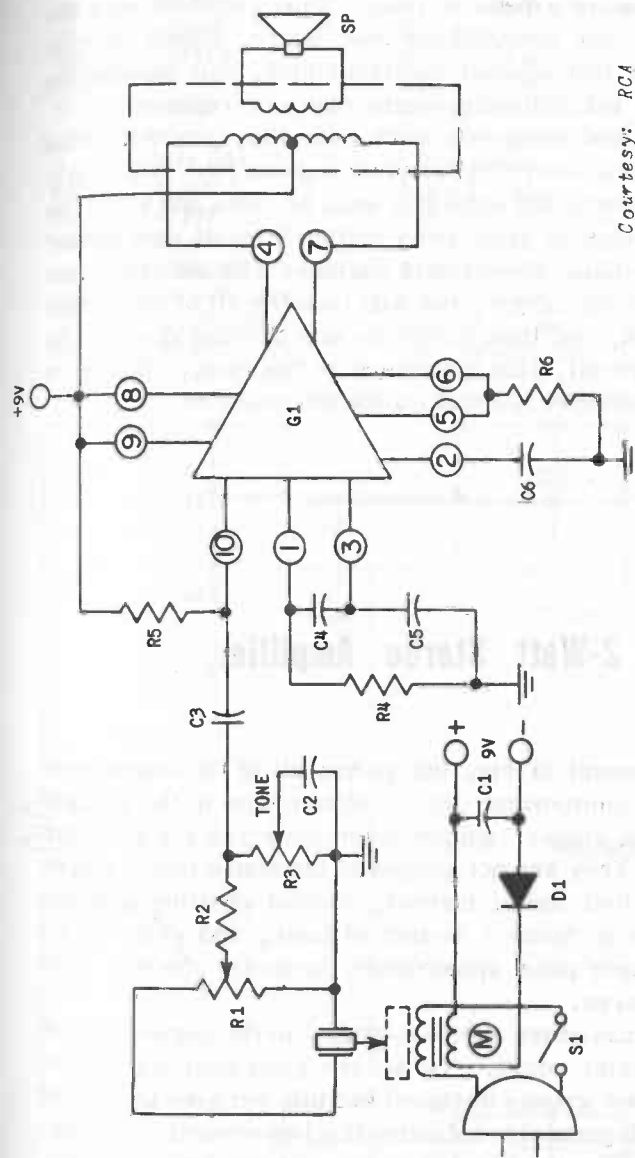
The circuit design approach uses a split power supply to provide a direct-coupled output to the speaker load. This permits full-rated output at all frequencies in the audio range to below 10 Hz. At the same time, low-frequency response can be limited as desired, and DC can be kept out of the speaker.

Input circuit Q1 and Q2 form a differential amplifier. Q1 is biased through a base-to-ground resistor. Q2, biased by a similar resistor, causes the output to be at equivalent ground because of the bi-symmetry of the local circuit. Q1 and Q2 are supplied as a dual unit and typical offsets of less than 10 mv are realized at the output. Q3 is a common-emitter driver stage. Since the output is an emitter-follower, Q3 must swing the full load voltage, plus saturation losses and output transistor transconductance. The output circuit is a full complimentary symmetry Darlington emitter-follower. If parasitic oscillations occur, add a .001-mfd capacitor directly across the bases of Q6 and Q7.

## IC Phono Amplifier

The glamour queen these days is the integrated circuit module, a little device which is simply wired into place, and lo and behold! It performs like a multitude of devices, simply because that's what it is. A typical IC application is this mono phonograph. In this circuit, power for the IC is drawn from a supply which uses a low-voltage tap on the phono motor winding. Check your 9-volt power supply before hooking up the IC or you might damage it. The cute idea here is to mount the entire IC circuit right in the tone arm!

Linear integrated circuits have established a firm foothold in such consumer product areas as TV receivers, high fidelity FM receivers, and phonographs. IC advances in consumer products can be traced to many factors, not the least of which



Courtesy: RCA

### CAPACITORS:

C1—400 pfd  
C2—4700 pfd  
C3—10 mfd  
C4, 6—5 mfd  
C5—.01 mfd

### RESISTORS:

R1—1 meg pot  
R2—330K  
R3—3 meg  
R4—5K  
R5—510K  
R6—.6 ohm

### PARTS LIST

IC: G1—CA3020

DIODE:

D1—Rectifier rated according to load

is economics. The reason for this rests primarily on the fact that manufacturers are loathe to introduce a new component until it is at least as inexpensive as the one it replaces. The IC may be more expensive than a transistor that does the equivalent job, but consider the cost fairly. Check the cost of the IC, not just against the transistor, but against the transistor and related components that are replaced.

The point is that when you work with ICs, you will often find that there are several types to do a given job. The hasty engineer who selects and searches until he finds one to do the job and then stops is effectively putting himself well behind the familiar 8-ball. The careful engineer will not stop when he finds one to do the job, but will look for all of those that can do his task, and then select the one of those that can do it best. This circuit, like the others in this book, has been designed around those ICs that do the job best.

## 2-Watt Stereo Amplifier

This is an economical rig, but it has all of the features of higher-priced commercial units. Notice that in the section before the input stages, ganged potentiometers are used for the controls. They are not ganged in the sense that a single shaft controls both units; instead, coaxial shafting is used. Certainly, this is more a matter of taste, and while it results in a cleaner panel appearance, separate controls may be used, of course.

The output transistors are heat-sinked to the copper foil of the printed circuit board. To assure good heat sinking, a layer of silicone grease designed for this purpose should be applied. The diagram also indicates that two separate printed-circuit boards are used for the separate amplifier stages. This is also a matter of taste, not an essential. For that matter point-to-point wiring would not be out of order—just be sure to heat sink the output transistors.

### PARTS LIST

#### TRANSISTORS:

- Q1, 2—T1S58
- Q3, 5—2N3704
- Q4, 6—2N3708
- Q7, 8—T1S90M
- Q9, 10—T1S91M

#### DIODES:

- D1, 2—1N2069

#### CAPACITORS:

- C1, 6—.0015 mfd
- C2, 7—.01 mfd
- C3, 8—560 pfd
- C4, 9—220 pfd
- C5, 10—.0056 pfd
- C11, 16—50 mfd, 30v
- C12, 15—5 mfd, 30v
- C13, 17—20 mfd, 20v

C14, 18—100 mfd, 30v

C19—500 mfd, 50v

C20—1000 mfd, 50v

#### RESISTORS:

R1, 7, 8—3.5 meg pot

R2, 9—180K

R3, 10—4 meg pot

R4, 11—220K

R5, 12—22K

R6—2.5 meg pot tapped at 1.4 meg from bottom

R13—2.5 meg

R14, 25—100 ohms

R15, 16, 26, 27—2K

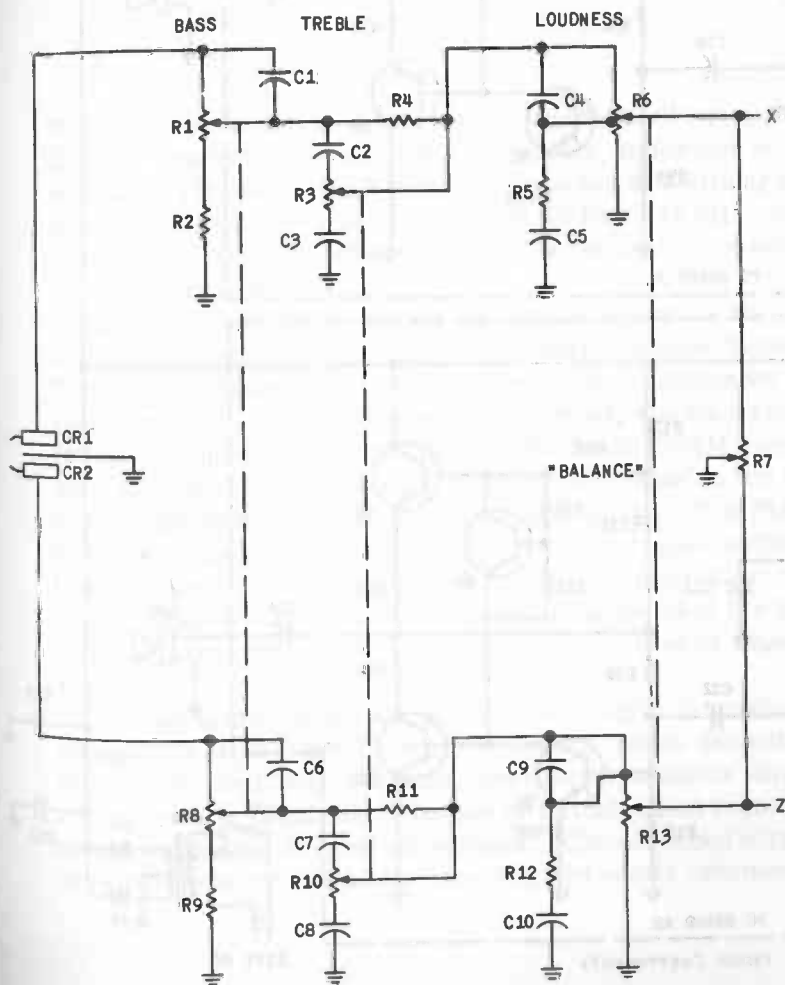
R17, 28—300 ohms

R18, 32—24K

R19, 33—1.3K

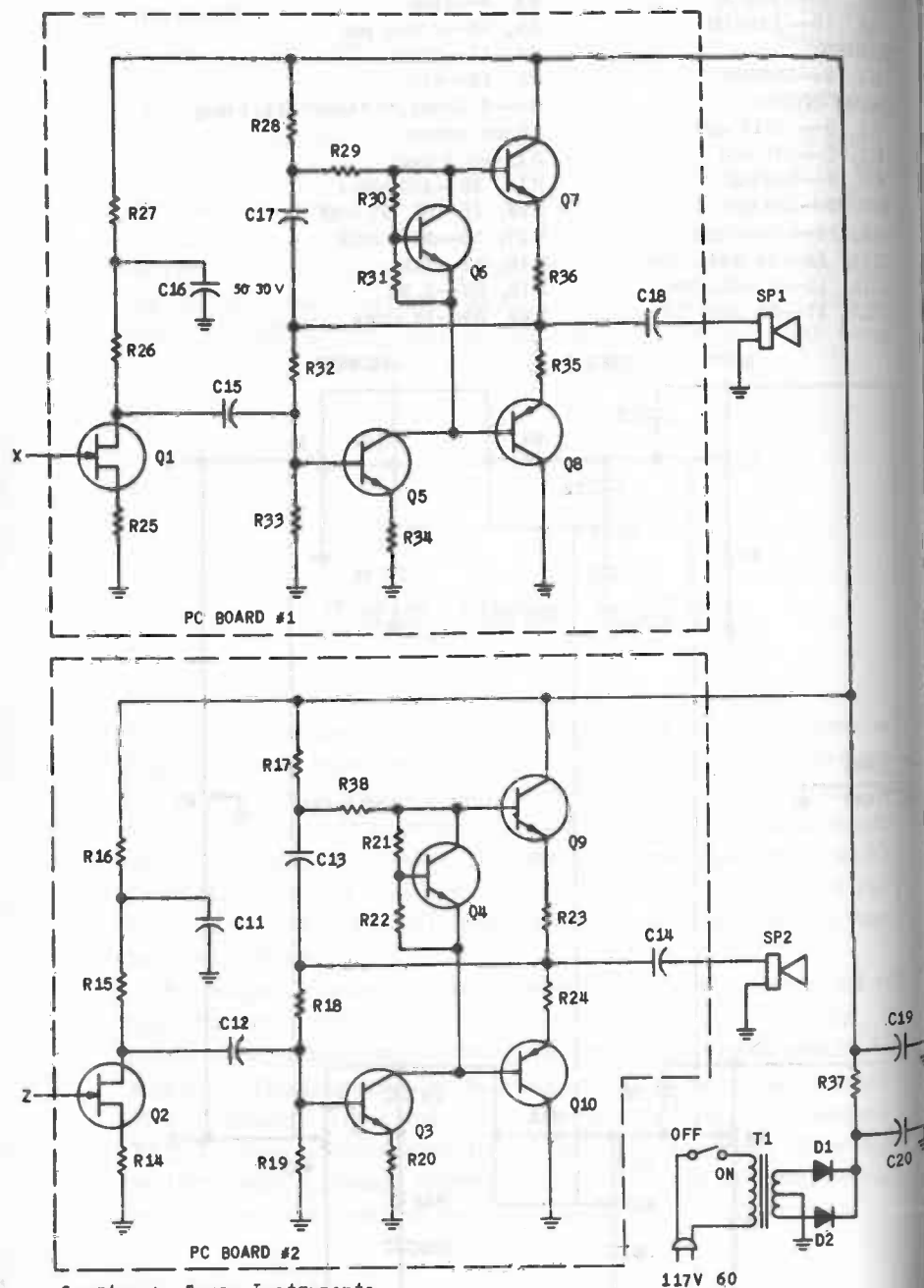
R20, 34—10 ohms

Cont.



R21, 30—200 ohms  
 R22, 31—360 ohms  
 R23, 24, 35, 36—3.9 ohms  
 R29—1.2K  
 R37—220 ohms

TRANSFORMER:  
 T1—Suitable power transformer,  
 CT secondary  
 MISCELLANEOUS:  
 CR1, 2—Sonotone 24T cartridge

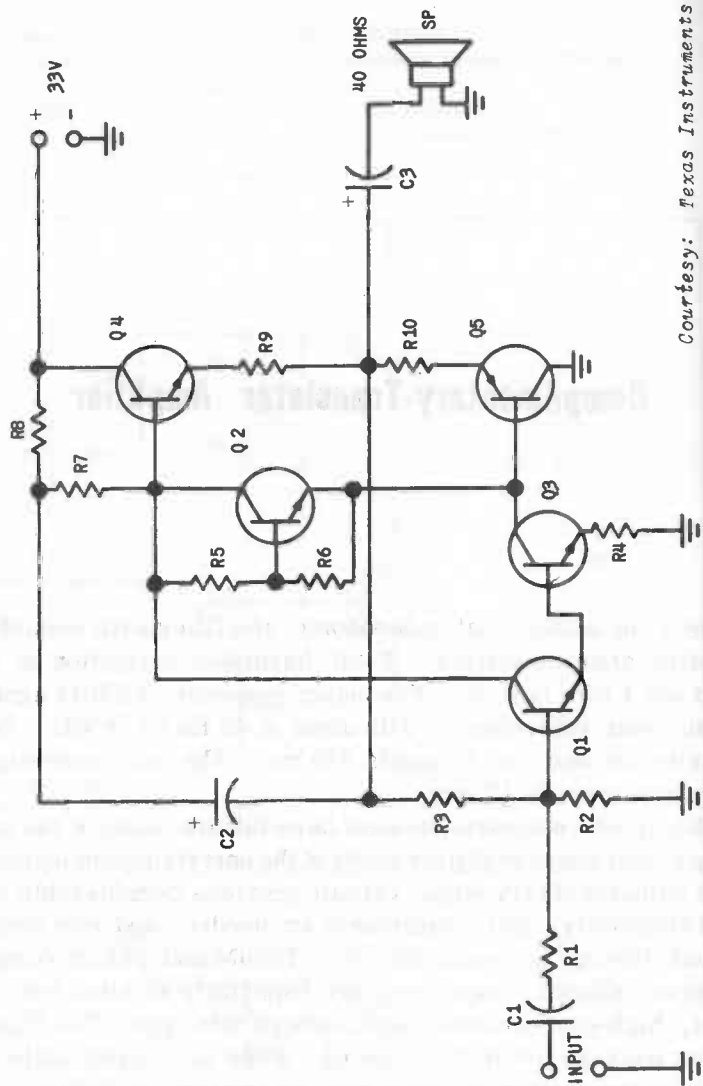


## Complimentary-Transistor Amplifier

Here's an economical monophonic amplifier with some high fidelity characteristics. Total harmonic distortion at one watt and 1 kHz is 0.8%. Frequency response at 1 kHz against a one-watt reference is 3 db down at 40 Hz to 18 kHz. Sensitivity for one watt output is 680 mv. The total zero-signal supply current is 13 ma.

The circuit configuration used here fulfills many of the one-to two-watt audio amplifier needs of the entertainment industry. The complimentary output circuit provides considerable circuit simplicity. No transformers are needed, and only single-ended driving is required. The TS90M and TS91M complimentary silicon transistors are especially suitable for low-cost, high-performance amplifiers of this type. The Plastic Silect package provides economy, while the copper collector lead on these units allows a high dissipation capability. The copper foil on the printed-circuit board can be used for heat-sinking, thus eliminating the need and extra cost of separate sinks.

The biasing method results in a simple, highly reproducible alternative to the use of series diodes. Diode selection is eliminated, and only a single, low-cost transistor and two resistors are required. The use of a field-effect transistor at the input has several advantages. Circuit simplicity and impedances in excess of one megohm are easily obtained.



#### PARTS LIST

##### TRANSISTORS:

Q1—2N3710  
 Q2—2N3708  
 Q3—2N3704  
 Q4—T1S90M  
 Q5—T1S91M

##### CAPACITORS:

C1—.1 mfd  
 C2—20 mfd, 20v  
 C3—100 mfd, 30v

##### RESISTORS:

R1, 2—220K  
 R3—2.2 meg  
 R4—10 ohms  
 R5—200 ohms  
 R6—360 ohms  
 R7—1.2K  
 R8—300 ohms  
 R9, 10—3.9 ohms

Courtesy: Texas Instruments

## Low-Noise Preamp for Low-Impedance Mikes

When transistors first hit the scene, the current joke was "What do you like better, tube hum or transistor hiss"? Today, with modern techniques, low-noise transistors have been produced that do away with that characteristic noise. However, if you build this unit, you'd better put it in a shielded box and use shielded cable for all external connections.

This circuit is designed for use with a dynamic mike or other low-impedance source. The amplifier is designed for an input impedance in the 50- to 250-ohm range. The transformer provides the necessary matching from the source output impedance to the optimum impedance for low transistor noise. Proper shielding of both the transformer and amplifier chassis is necessary for low-noise operation. Equivalent input noise voltage vs ambient temperature is found by measuring output noise EMF with the input short-circuited. Divide this figure by the voltage gain. ( $A_v=1000$  at  $25^{\circ}\text{C}$ ). Typical input noise voltage at  $25^{\circ}\text{C}$  is  $4\ \mu\text{V}$ . Other circuit characteristics? Up to 6 mv input voltage, 1% maximum distortion,  $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$  operation, and a 54 mw power supply drain.

#### PARTS LIST

##### TRANSISTORS:

Q1, 2, 3—2N780

##### DIODE:

D1—1N753A

##### CAPACITORS:

C1—33 mfd, 6v  
 C2—10 mfd, 35v  
 C3—10 mfd, 20v

##### RESISTORS:

R1—250 ohms  
 R2—38.3K

R3—51.1K

R4—750K

R5—61.9K

R6—200K

R7, 8—20K

R9—16.2K

R10—3.01K

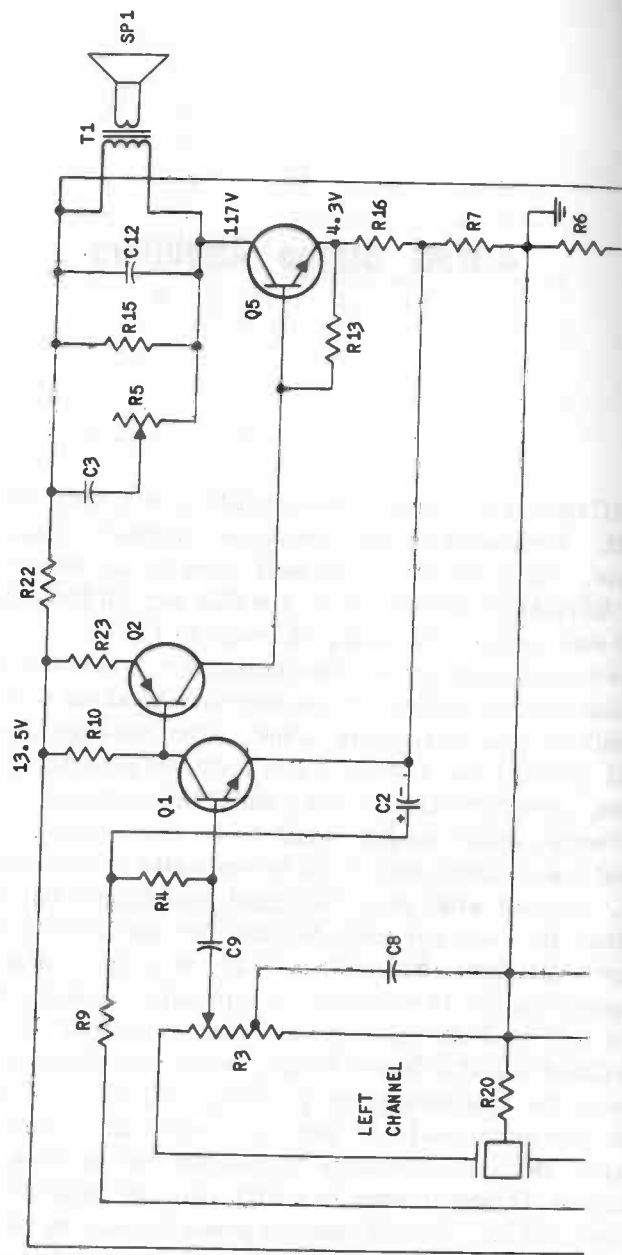
R11—475 ohms

##### TRANSFORMER:

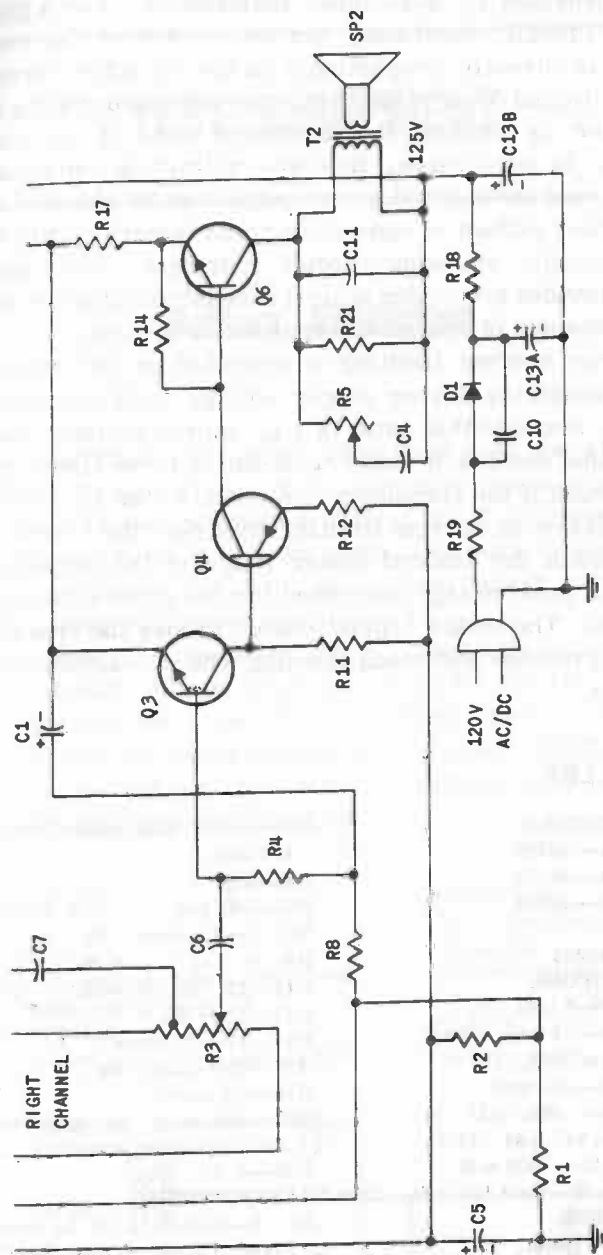
T1—1:5 ratio, primary, 1600 turns #40; secondary 1600 turns #40; core size E121







Courtesy: RCA



parallel resonant circuit, with series and shunt damping elements provided by associated resistances. For a given set of load circuit conditions, the peak value of the transient voltage is directly proportional to the collector current and can be limited to a value within the maximum rating for the transistor by limiting the maximum value of the collector current. In most cases, this type of limiting can be accomplished, and the desired power output can be obtained without clipping and without compromising cost factors. This is done by judiciously choosing circuit constants. The amplifier shown provides protection against excessive collector voltages without the use of transient-suppression devices.

Collector current limiting is provided by the ratio of the output transistor driver supply voltage to the emitter-base voltage. Because this ratio is 3:1, approximately, the most current that can flow in this transistor is three times the bias current even if the transistor is shorted to the 13.5-volt supply. This type of current limiting does not effect the dynamic range within the desired power range of the amplifier. It limits the peak voltage developed for the given collector load constants. The treble control placed across the transformer primary provides additional damping with no sacrifice in performance.

#### PARTS LIST

##### TRANSISTORS:

Q1, 3—40399  
Q2, 4—40359  
Q5, 6—40424

##### DIODE:

D1—40265

##### CAPACITORS:

C1, 2—5 mfd, 3v  
C3, 4—.1 mfd, 200v  
C5—100 mfd, 15v  
C6, 9—.01 mfd  
C7, 8—.0022 mfd  
C10—.047 mfd, 400v  
C11, 12—.005 mfd  
C13A, B—dual 100 mfd, 150v

##### RESISTORS:

R1—82 ohms, 5%  
R2—1K, 5%

R3—5 meg dual control tapped at

1.5 meg

R4—47K

R5—50K pot

R6, 7—11 ohms, 5%

R8, 9, 10, 11—8.2K

R12, 13, 14, 23—1K

R15, 21—18K

R16, 17—82 ohms

R18—200 ohms, 4w

R19—68 ohms

R20—68K (may be replaced by .047-mfd 400v capacitor)

R22—6.8K, 2w

##### TRANSFORMERS:

T1, 2—output, 2.5K to speaker.  
Freed RGA-8, Triad S-62X or equiv.

## TEST EQUIPMENT

### Battery Eliminator

If you experiment with solid state, you need operating voltages in a range that eats up batteries as fast as you can buy them. This circuit provides a variety of DC voltages and will soon pay for itself in battery costs. R1 permits you to vary the voltage output, and you can read the supply voltage level by multiplying the meter reading by 10.

Transformer T steps down the AC line to 12 volts. This is then rectified by silicon diode rectifiers D1 and D2. The output of the full-wave rectifier is filtered by C1, which also holds the voltage level reasonably constant. While the output ripple percentage may leave something to be desired, it is suitable for many applications.

#### PARTS LIST

##### DIODES:

D1, 2—silicon power rectifiers.  
Rating should equal T1.

##### CAPACITOR:

C1—1000 mfd, electrolytic, 25v

##### RESISTORS:

R1—100-ohm pot, 2w

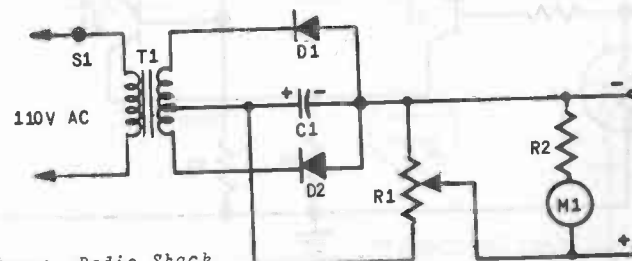
R2—10K

##### TRANSFORMER:

T1—110-12.6vct

##### MISCELLANEOUS:

M1—0-1 ma



Courtesy: Radio Shack

## No-Contact Switch

Sensistors are silicon resistors used as temperature compensators or indicators in various types of circuits. They're available in power ratings of 1/8 to 1/4 watt. By using a sensistor in the bias circuit of a Schmitt trigger, a temperature change causes the trigger output to change states. The sensistor in this diagram is the sensing element. When a sufficient temperature change occurs, the resistance of the device is high enough to cause the trigger to switch. By properly selecting values, the circuit can be operated to a point where the change is irreversible.

### PARTS LIST

#### TRANSISTORS:

Q1, 2—2N2537

#### RESISTORS:

R1—50K pot

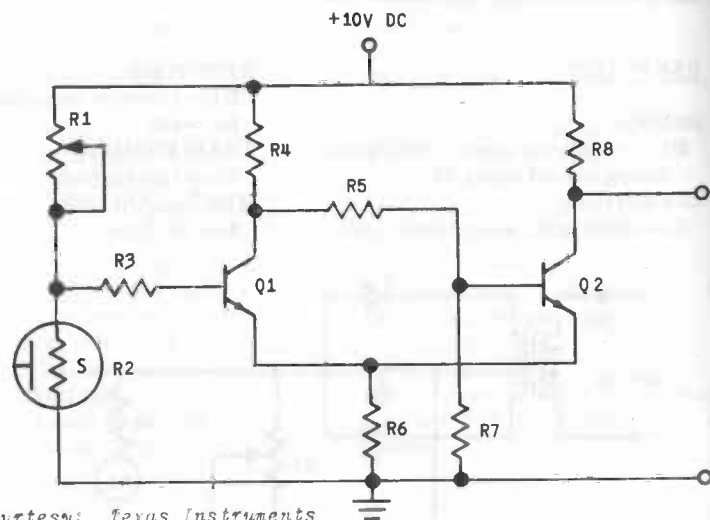
R2—5.6K sensistor

R3, 5—680 ohms

R4—1.5K

R6—330 ohms

R7, 8—10K



Courtesy: Texas Instruments

## Sensistor Temperature Indicator

Here is another heat-sensing circuit, also employing a sensistor. At room temperature the 100-volt source is dropped equally across R1 and sensistor R2. As the sensistor is heated, its resistance increases and the voltage across the R2/I1 circuit increases, and when it reaches the firing point of the lamp, I1 lights. The lamp firing temperature is determined by the choice of sensistor and the potentiometer setting.

There are many applications for this circuit. For example, it can be used as a safety indicator for machines that must be limited in temperature rise; in fact, it can serve in many circumstances where temperature rise is a significant factor. However, according to the local fire nabobs this circuit is inefficient as a fire alarm. They tell us that while fire does indeed cause damaging heat, the biggest danger is not from fire but from smoke. By the time the heat from a fire does

### PARTS LIST

#### RESISTORS:

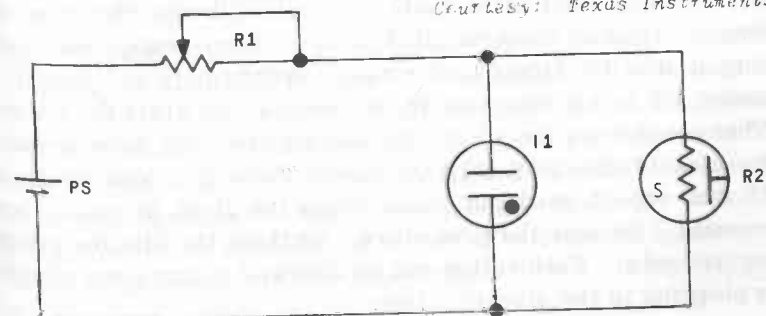
R1—10K

R2—10K sensistor

#### MISCELLANEOUS:

I1—NE2 neon lamp

PS—100v power supply



Courtesy: Texas Instruments

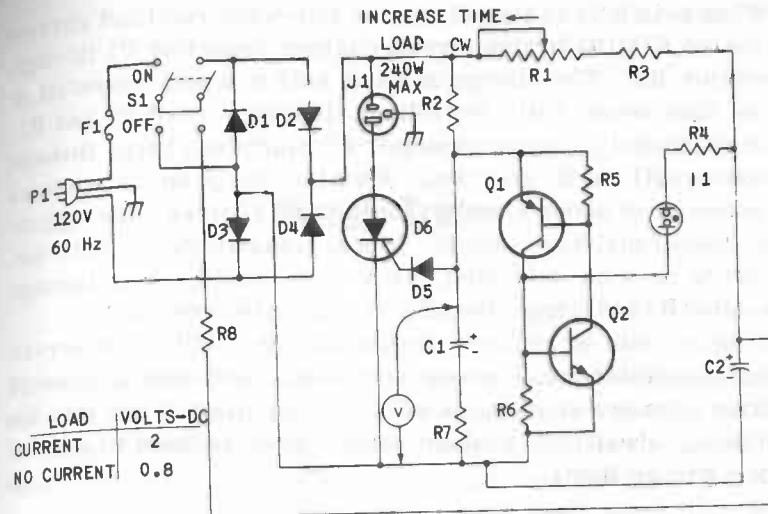
its damage, chances are the smoke will first have taken its toll and the alarm will sound on deaf ears.

If you feel that the light is insufficient as an indicator, an NE-2H neon lamp can be substituted for the NE-2, and use a photovoltaic cell to indicate the lamp ignition by ringing a bell, or you can fully automate the system by having the photocell close a relay, turning off a piece of equipment when its temperature reaches a predetermined level. In other cases, the device can be used to turn on equipment when the ambient temperature rises, such as an air conditioner or a fan.

## Electronic Timer

An electronic timer is quite useful on many occasions, but if you are at all interested in photography, the value of this device zooms. Connected to an enlarger it helps to accurately control the light duration. Looking at the schematic, you will notice that this system uses a 3-wire grounded plug. Don't play games with this—that third wire ground is vital! If the tuner is to be used in a photographic darkroom, you know the place can get pretty sloshy with all kinds of wetness around.

The most important aspect of this timer is the calibration of potentiometer R1. Don't let this throw you. Here is an ultra simple (and ultra fast) way to calibrate this type of timer. Take an electric clock with a sweep-second hand and plug it into the timer load socket. Arbitrarily set potentiometer R1 to a given point in its rotation and start the timer. When you initiate the start, the second hand will move around the face of the clock until the timer shuts off. Now readjust R1 and repeat until the timer stops the clock in exactly ten seconds. Repeat the procedure, marking the dial for every ten seconds. Calibration can be checked at any time simply by plugging in the electric clock.



LOAD CURRENT	VOLTS-DC
CURRENT	2
NO CURRENT	0.8

Courtesy: ECA

### PARTS LIST

#### TRANSISTORS:

Q1—KD2101  
Q2—KD2102

#### DIODES:

D1 to D4—KD2103  
D5, 6—KD2100 SCR

#### CAPACITORS:

C1—50 mfd, electrolytic, 15v  
C2—50 mfd, electrolytic, 150v

#### RESISTORS:

R1—1 meg pot, 2w linear

R2—3K, 5w

R3—47K

R4—10K

R5—150 ohms

R6—470 ohms

R7—33 ohms

R8—15 ohms

#### MISCELLANEOUS:

F1—3 amp

I1—G.E. NE83

P1, J1—3-wire plug and receptacle (see text)

## Electronic Time Delay

This circuit is used to delay power application to a load for a predetermined period after the control switch is turned on. It can be used with any AC/DC device that does not employ a chassis ground and have a total power rating in excess of 240 watts. The delay time can be adjusted by potentiometer R1 from five seconds to about two minutes. The delay is determined by the length of time required to charge capacitor C2 to the value needed to cause neon lamp I1 to fire. This triggers the 2-transistor electronic switch.

When switch S1 is turned on, the full-wave rectified current from the KD2103 bridge circuit charges capacitor C1 through resistor R2. The charge on C1 is held to a peak potential of less than seven volts by voltage divider circuit R2 and R7. Simultaneously, timing capacitor C2 starts to charge through resistors R1 and R3 in series. When the charge on C2 achieves a potential of about 80 volts, neon lamp I1 fires and triggers the two-transistor switch. When transistors KD2101 and KD2102 become saturated, they complete the gate through resistor R8 and trigger the silicon controlled rectifier.

Coupled with an auditory device such as a bell, this serves as a repeatable delay before actuation. Used with a solenoid to trip a camera shutter, it will allow you time to get into the picture. Used with a slave relay, it can be used to control your garage lights.

#### PARTS LIST

##### TRANSISTORS:

Q1—KD2101

Q2—KD2102

##### DIODES:

D1 to D4—KD2103

D5—KD2100 SCR

##### CAPACITORS:

C1—50 mfd, electrolytic, 15v

C2—50 mfd, electrolytic, 150v

##### CAPACITORS:

R1—1 meg pot, 2w linear

R2—3K, 5w

R3—47K

R4—10K

R5—150 ohms

R6—470 ohms

R7—180 ohms

R8—100 ohms

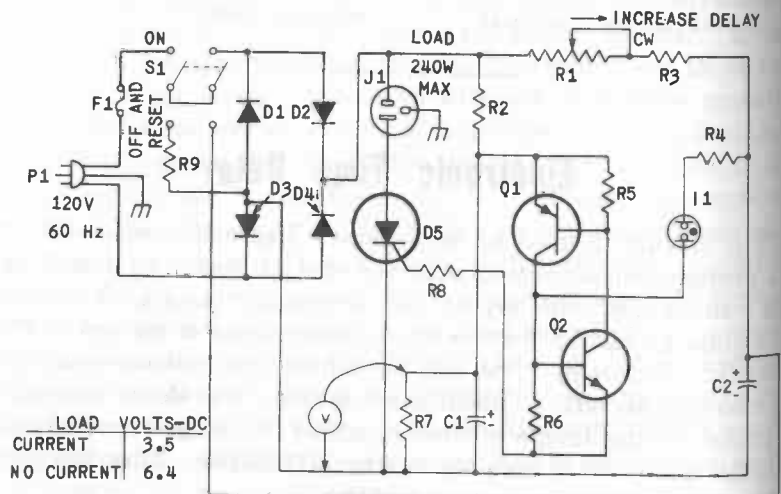
R9—33 ohms

##### MISCELLANEOUS:

F1—3 amp

I1—NE-83 neon

P1, J1—3-wire plug and receptacle



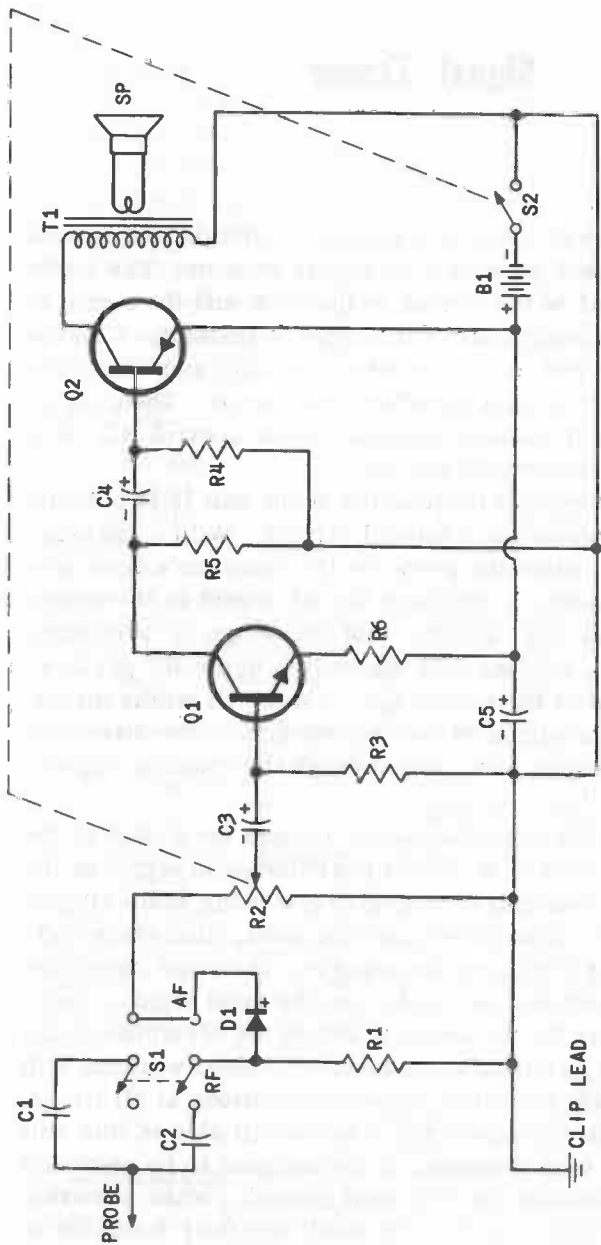
Courtesy: RCA

## Signal Tracer

The signal tracer is actually a passive device in that it does not serve as a signal generator or signal injector. The probe is simply touched to the circuit in question and the signal is heard through the loudspeaker, if a signal is present. Closely resembling a typical receiver detector-audio amplifier circuit, diode D1 serves as a rectifier or detector. Then, after the detected signal passes through volume control R2, it is amplified by transistors Q1 and Q2.

The best way to describe the function of the unit is to actually step-by-step troubleshoot a typical circuit. With a radio receiver turned on, place the probe on the receiver's first amplifier plate terminal. If you hear the RF signal in the tracer loudspeaker, you can assume that the stage is operating. This, of course, is done with the switch in the RF position. Move to the grid of the next stage, which will be the mixer. Again, hearing the signal at the control grid of the mixer indicates that the signal has come through the coupling capacitor.

After you pass the detector stage, change the switch to the audio position. Now you should hear the audio signal in the tracer speaker. Continue from grid to grid in the audio stages. If the signal fails to be present at any point, that stage and/or its associated circuitry are suspect. Because capacitive coupling is used between the probe and the input signal, there is no need to fear the presence of DC on the terminals being tested. However, remember that you are indeed working with a live circuit, and exercise proper precautions at all times. By using miniature components, the overall size of this unit can be reduced considerably. It is designed to be grounded to the unit under test by the clip-lead ground. Make sure that the ground lead wire and the clip itself are fully insulated to avoid accidental grounding to associated circuits.



Courtesy: Radio Shack

**PARTS LIST**

**TRANSISTORS:**

Q1—2N707

Q2—2N104

DIODE:

D1—1N34

**CAPACITORS:**

C1—.05 mfd

C2—100 pfd

C3, 4—2 mfd, electrolytic, 12v

C5—10 mfd, electrolytic, 12v

**RESISTORS:**

R1—100K

R2—25K pot

R3, 4—270K

R5—4.7K

R6—91 ohms

BATTERY:

B1—9V

TRANSFORMER:

T1—suitable output transformer

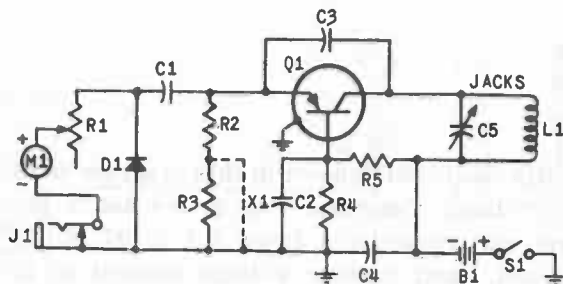
## Grid Dip Oscillator

The grid dip oscillator shown in this diagram is designed to perform two basic functions—an active and a passive test instrument—at frequencies from 3.4 to 97 MHz. With the switch closed, and battery voltage applied to the circuit it is an active grid-dipper and a low-power signal generator. In this mode a signal is generated at a frequency determined by tank circuit L1/C5. When the grid-dip oscillator is brought near a resonant circuit whose frequency corresponds to the frequency of the L1/C5 circuit, a portion of the current generated in that circuit is drawn off, causing a reading to occur on the meter M1. By calibrating the capacitor, you can read the frequency directly. Use a different calibration scale for each plug-in coil. The meter reading at resonance will go down, hence the name grid dip.

In its other mode, that of a passive device, the grid dipper can be used with the switch open. Bring it close to an active circuit and tune capacitor C5 for an increase in the meter reading. The meter will tell you when you have reached resonance, and in this way you will be able to determine the frequency of an external circuit. The meter reading will indicate over-coupling in all cases, providing a slight rise before and after the ultimate dip. Similarly, when used passively with an active circuit, the meter will dip slightly before and after reaching the maximum peak.

In the passive mode, the oscillator can be used as a relative field strength indicator. Used with any transmitter, and tuned to the transmitter's frequency, you can tune the transmitter to optimum output with no difficulty at all. In this same way, it also becomes a valuable counter-bugging tool. With power

removed, you simply tune the unit through the ranges most frequently used by electronic surveillance equipment, namely the citizens frequencies and the FM frequencies. If a hidden transmitter is indeed putting out a signal, the meter will show a peak when its frequency is neared. You can then adjust sensitivity control R1 and move around the room looking for a peak. In this fashion, you will know when you are getting closer to the hidden unit.



Courtesy: RCA

#### PARTS LIST

##### TRANSISTOR:

Q1—2N1178

##### DIODE:

D1—1N34A

##### CAPACITORS:

C1—33 pfd, mica, 50v

C2—0.01 mfd, paper, 50v

C3—5 pfd, mica, 50v

C4—0.01 mfd, paper, 50v

C5—variable capacitor, 50 pfd (Hammarlund type HF-50 or equiv.)

##### RESISTORS:

R1—250K pot

R2—220 ohms

R3—3K

R4—3.9K

R5—39K

##### BATTERY:

B1—13.5v, RCA VS304

##### COILS:

L1—plug-in coil (see table)

##### MISCELLANEOUS:

M1—microammeter, 0 to 50  $\mu$ a (Simpson model 1227 or equiv.)

X1—jumper, omit for measurements below 45 MHz

J1—phone jack, normally-closed

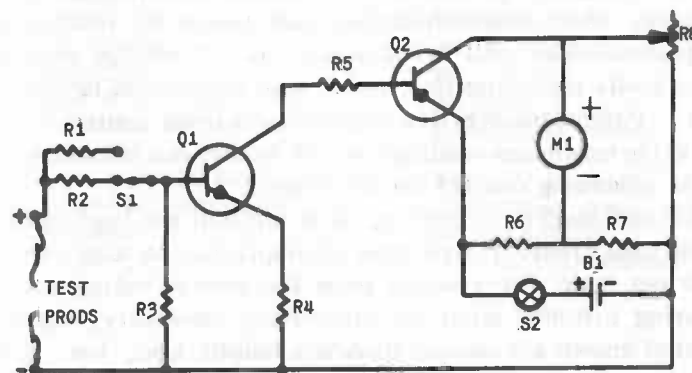
#### COIL-WINDING DATA

Coil Freq. Range	Wire Size	No. of Turns
1 3.4-6.9 MHz	#28 enamel	48 1/4, close wound
2 6.7-13.5 MHz	#24 enamel	22, close wound
3 13-27 MHz	#24 enamel	9 1/8, close wound
4 25-47 MHz	#24 enamel	4 1/8, close wound
5 46-78 MHz	#24 enamel	1 1/2, close wound
6 74-97 MHz	#16 tinned	hairpin formed, 1 7/8 inches long including pins, and 1.4 inch wide

Coil forms are Amphenol type 24-5H or equivalent.

## Simple Voltmeter

The transistorized voltmeter, like the vacuum-tube voltmeter, has a decided advantage over the nonelectronic types. You may have noticed on your nonelectronic voltmeter the legend "20,000 ohms per volt." This means that for every volt the unit measures, you will load your circuit under test by quite a bit of resistance. The electronic voltmeter (transistor or vacuum tube) does not load the circuit at all. This can be important in some circuits where adding an additional load will make for inaccurate readings.



Courtesy: Radio Shack

#### PARTS LIST

##### TRANSISTORS:

Q1—2N357

Q2—2N270

##### RESISTORS:

R1—1 meg

R2—100K

R3—10K

R4—100 ohms

R5—1K

R6, 7—470 ohms

R8—5K pot

##### BATTERY:

B1—1.5v

##### MISCELLANEOUS:

M1—0-1 ma

With the electronic meter, you just don't have this problem. As a result, you get more accuracy in critical readings, whether you are testing a hi-fi amplifier, a ham transmitter, or a television circuit. You'll also find that this unit is not



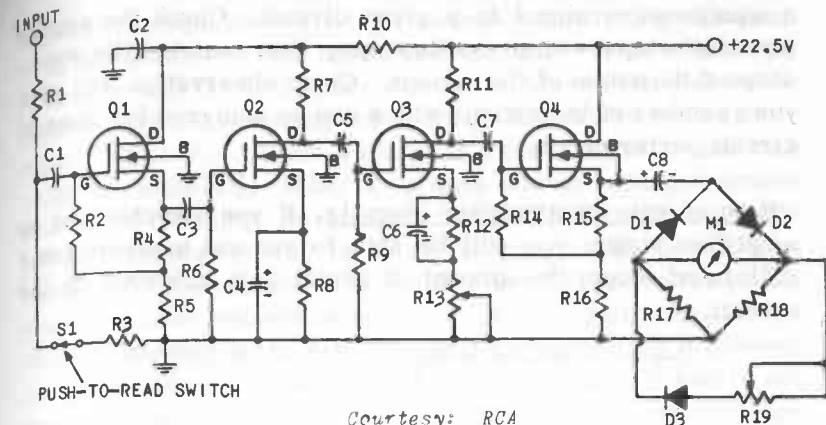
just highly accurate, it retains its accuracy. Part of the reason for this is that transistors do not heat up the way vacuum tubes do; therefore, components won't change value as quickly as they age. For even more accuracy, use 1% resistors in the critical circuits.

## AC Voltmeter

This meter circuit operates from a 22-1/2 volt battery source and is designed primarily for reading alternating-current voltages, which makes it an ideal instrument for testing audio equipment. The unit is basically an AC voltage amplifier which feeds its output to a meter with a balanced bridge rectifier. Potentiometer R13 serves as a level control for establishing maximum readings on the scale, and potentiometer R19 is a zeroing control for the meter.

Like any electronic meter, this unit will not load down the circuit under test. Four stages of amplification also provides sufficient gain for reading even the lowest voltages. The metering circuits must be calibrated, obviously, against a meter of known accuracy. Here's a helpful hint, too. Carefully remove the meter movement from its case and the two mounting screws that hold the scale in place. With an ordinary pencil eraser, carefully remove the milliamper values and replace them with AC voltage markings, using India ink and a quill pen.

The push-to-read switch in no way effects the battery voltage, which remains on constantly. If this voltmeter is to be incorporated with a piece of equipment, all well and good. The meter circuit will be on only when the equipment is on and the switch will provide readings when it is pressed. However, for most applications we would like to see a second switch added in series with the supply voltage, so that if a battery is used to power the circuit, it will not be under constant drain.



Courtesy: RCA

### PARTS LIST

#### TRANSISTORS:

Q1 to Q4—40461

#### DIODES:

D1 to D3—1N34

#### CAPACITORS:

C1—0.01 mfd, paper, 600v

C2—25 mfd, ceramic disc, 25v

C3, 5, 7—0.33 mfd

C4, 6—100 mfd, electrolytic, 6v

C8—50 mfd, electrolytic, 25v

#### RESISTORS:

R1—1K

R2—10 meg

R3—100 ohms

R4, 8, 12—10K

R5—47K

R6, 9, 14—390K

R7, 11—33K

R10—5K

R13—1K pot, linear

R15—2K

R16, 17, 18—5.1K

R19—1K pot, linear taper

#### MISCELLANEOUS:

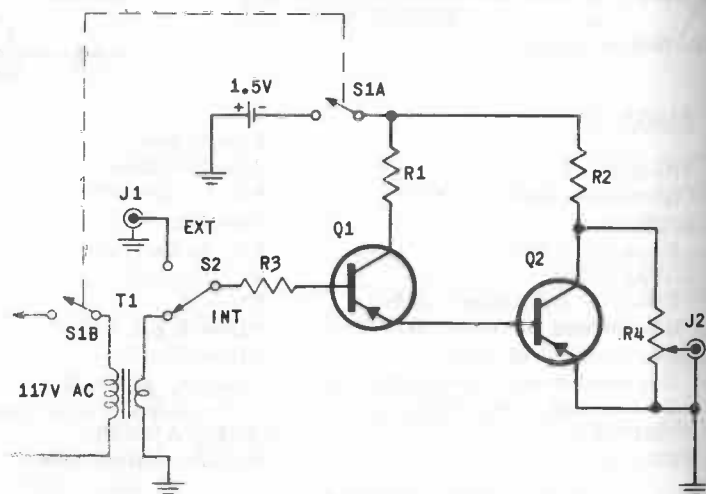
M1—DC milliammeter

## Square-Wave Generator

Since the square-wave generator provides a pulse equally positive and equally negative, it serves well in computer circuitry. Triggered by an external pulse, it can be used as an electronic switch as well. Also, because of its associated transients and sharp rise and fall times, a square-wave signal is very useful in analyzing amplifier circuits and, in fact, any circuit designed to pass or process any AC signal. Apply

a square-wave signal to a given circuit. Check the square wave at the input with an oscilloscope, then examine the wave-shape at the output of the circuit. Close observation will give you a number of indications which can be analyzed for overall circuit performance:

Rate of gain in amplifier circuits: If you are checking an amplifier stage, you will be able to see and measure (on a calibrated scope) the amount of actual gain achieved by the circuit.



Courtesy: Radio Shack

#### PARTS LIST

TRANSISTORS:	R3—100K
Q1, 2—2N104	R4—50K pot
RESISTORS:	TRANSFORMER:
R1, 2—510 ohms	T1—6v filament transformer

Distortion: As the input is a square wave, any distortion will be immediately apparent on the scope. Look for rounding of the corners, sloping of the rise or fall.

Noise impingement: Should your circuit add noise or other interference to the signal, this will be apparent in the form of vertical spikes on the display.

This unit is handy for checking out hi-fi equipment, and provides either a sine or a square wave. Often, in checking

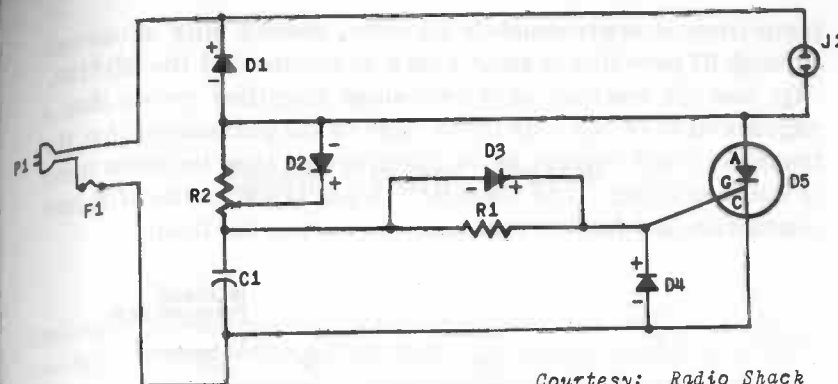
high fidelity equipment you try to depend on audio signals from program material. It's hard, for example, to determine the proper setting for the balance control on stereo channels when stereo sound is bouncing out of the loudspeakers from left to right! Bi-level channel volume is equally hard to set with program material. Many of us have attempted to get around this by purchasing stereo test records. Unfortunately, the record manufacturers, in an effort (misguided, perhaps) to make their records more versatile, provide more tests than you might have immediate need for. As a result, the steady-state frequency tests are too short for more than a moment or two of sound, allowing you to determine only if you're set properly or improperly—not enough to allow you to truly adjust. With this unit you plug into the input jack and have a steady-state tone permitting you to make adjustments to your heart's content.

## POWER CONTROLLING CIRCUITS

### AC Voltage Control

This full-wave circuit provides symmetrical control from zero to 100% over an AC load. It can serve as a dimmer for incandescent lamps and to control the speeds of AC motors. During the positive half-cycle, the arm of the potentiometer samples the supply voltage and compares it with the back voltage of the motor or load through the gate terminal of the SCR. When the primary voltage rises above that of the rectifier, the SCR is triggered by diode D2 which applies the remainder of that half-cycle voltage to the load at the controlled level. D1 suppresses the inductive spikes that would be created when this circuit is used in controlling a motor. When you limit the applications of this unit to controlling incandescent lamps only, D1 isn't required.

Some additional applications for this unit include light control for projecting slides or home movies. People do not like to be plunged abruptly into darkness from a lighted room, and with this unit you can gradually scale down the room lighting as the film gets started. This also gives the projectionist a chance to see that film loops are properly formed before he plunges into darkness!



Courtesy: Radio Shack

#### PARTS LIST

##### DIODES:

D1 to D4—1N34

D5—SCR, 6 amp, 200 PIV

##### CAPACITOR:

C1—1 mfd

##### RESISTORS:

R1—33K, 1w

R2—100K pot

##### MISCELLANEOUS:

F1—5 amp

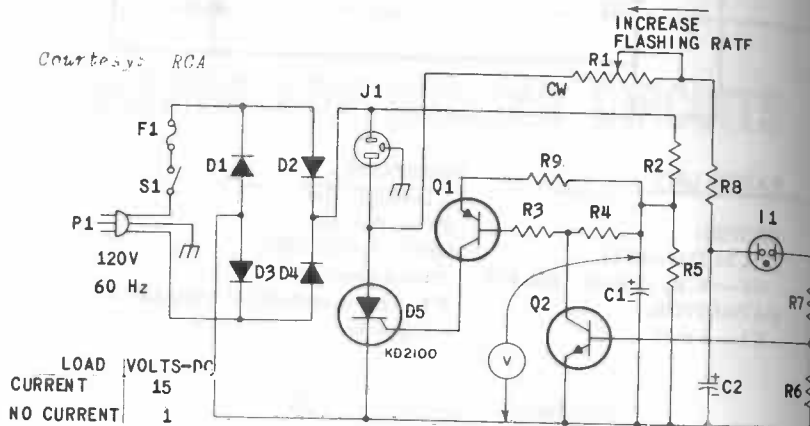
P1, J1—standard AC plug and receptacle

### SCR Current Control

Here is a flasher circuit capable of switching 240 watts worth of advertising signs, Christmas tree lights, or anything else that needs "on and off." Used with an auditory device, it becomes a fine variable speed metronome. When switch S1 is closed, pulsating DC voltage from the KD2103 bridge rectifier is applied across the load and the parallel SCR and resistance-capacitance circuit C2, R1, and R8. Since the SCR is in a passive state, the load current is low. As a result, input pulses charge C2 to the neon lamp firing potential. When the

lamp fires at approximately 80 volts, about 2 mils of current through R7 provides an input signal to the base of the KD2102.

Q1 and Q2 operate as a two-stage amplifier rather than a regenerative switch. R6 in the base of Q2 guarantees that the transistor will remain in the cutoff mode when the neon lamp is not conducting. The amplifier output triggers the SCR into conduction and full current appears across the load.



#### PARTS LIST

##### TRANSISTORS:

Q1—KD2101

Q2—KD2102

##### DIODES:

D1 to D4—KD2103

D5—KD2100 SCR

##### CAPACITORS:

C1—50 mfd, electrolytic, 15v

C2—50 mfd, electrolytic, 150v

##### RESISTORS:

R1—10K pot, 2w linear

R2—3K, 5w

R3, 4—2.2K

R5—680 ohms

R6—47K

R7—4.7K

R8—22K

R9—150 ohms

##### MISCELLANEOUS:

I1—NE-83

F1—3 amp

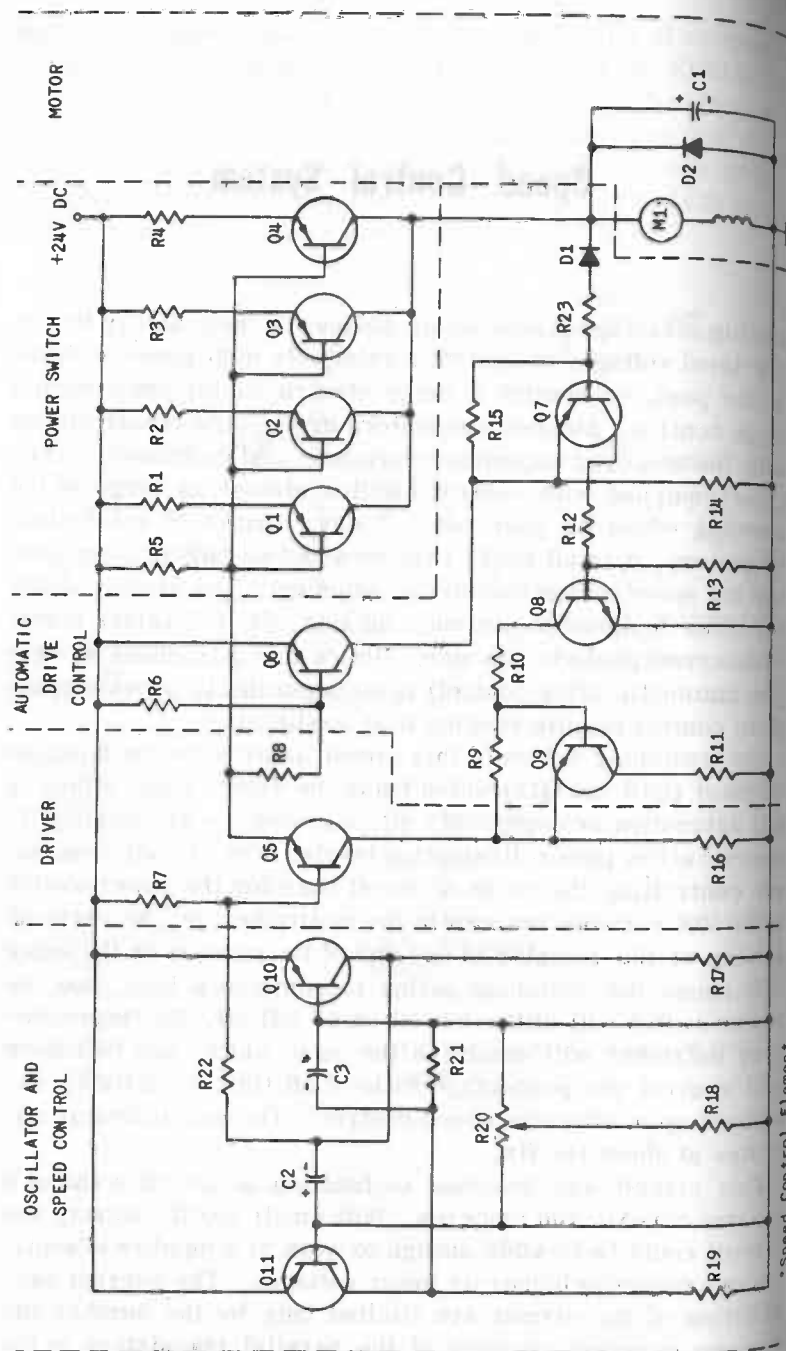
P1, J1—3-wire AC plug and receptacle

## Speed Control System

One big advantage of solid-state devices is their ability to use low-level voltages to control a relatively high-power circuit. In the past, to control a large electric motor you needed a large control. Stepped attenuators or variable transformers with the required capacities were huge and expensive. They came equipped with control handles almost as large as the steering wheel on your car! Today, thanks to solid-state technology, a small knob, twisted with two fingers, can control the speed of huge industrial equipment. The circuit shown here was designed to control a 20 amp, 24v DC series motor with current peaks to 100 amp. Notice that a feedback system (the automatic drive control) is incorporated to provide complete control despite varying load conditions.

The switching action of this circuit is provided by a multi-vibrator (Q10 and Q11) which holds the driver stage either in full saturation or completely off, allowing the driver stage to operate at low power dissipation levels. The circuit component controlling the ratio of on-off time for the power switch is the 50K variable resistor in the multivibrator. An extreme setting of the resistor to one end of its rotation or the other will cause the switching action to come to a halt, and the power switch will either be full on or full off. Settings other than extremes will establish the pulse width, and therefore will control the percentage ratio of off time to on time, establishing an effective speed control. The multivibrator operates at about 100 Hz.

This circuit was designed to function at 24 volts and at a current close to 100 amperes. With small modifications, the circuit could be flexible enough to work at a number of applications requiring higher or lower voltages. The current capabilities of the circuit are limited only by the number and current carrying capacity of the parallel transistors in the power stage.



Courtesy: Texas Instruments

## PARTS LIST

### TRANSISTORS:

Q1 to Q4—2N514  
 Q5—2N511  
 Q6, 7, 9—2N1372  
 Q8—2N1302  
 Q10—2N1038  
 Q11—2N1373

### DIODE:

D1—1N2069  
 D2—depends on motor

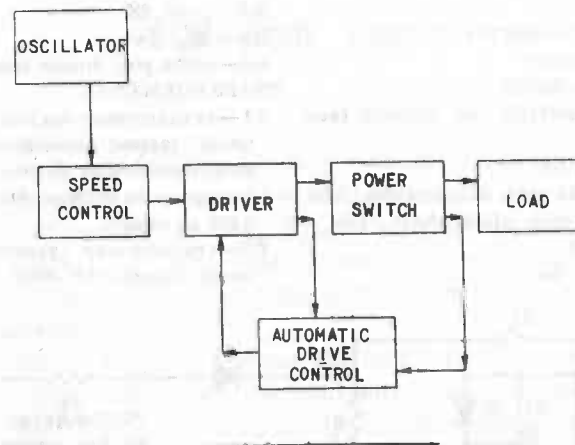
### CAPACITORS:

C1—16 mfd, electrolytic, 100v  
 C2—.5 mfd  
 C3—10 mfd

### RESISTORS:

R1, 2, 3, 4—.05 ohms

R5—10 ohms  
 R6, 9, 12, 13, 14, 15—1K  
 R7—100 ohms, 2w  
 R8—200 ohms  
 R10—100 ohms  
 R11—40 ohms  
 R16—20 ohms, 20w  
 R17—30 ohms, 5w  
 R18—270 ohms  
 R19—500 ohms  
 R20—50K pot  
 R21—191 ohms  
 R22—50 ohms, 5w  
 R23—478 OHMS  
 MISCELLANEOUS:  
 M1—20 amp



## Integral Cycle Ratio Power Control

This transistorized integral cycle ratio power control is good for controlling an electric hotplate, for example, where control of the average power level is desired. This unit needs no thermostatic control, either. Simply plug the hotplate into the load socket and set R6 for the desired heat level you wish to maintain. It's also great for keeping an electric coffee pot

hot. Wherever you want a relative ratio control for alternating current loads, you'll find this circuit handy. Another typical example of where this might be used is in alternating current electric motors—in some hand tools, for instance. This circuit could be easily built right into the tool housing, and R6 could be coupled to a spring-return trigger. This would result in infinitely variable speed control for the tool with the speed a direct function of trigger position at any given time.

Q2 and Q3 form a free-running multivibrator, with the repetition rate controlled by balancing potentiometer R6. The outputs are applied from the collector of Q2 through Q1, and

#### PARTS LIST

##### TRANSISTORS:

Q1—2N2614  
Q2, 3—2N3241

##### DIODES:

D1, 3, 7—1N3754  
D2—1N1199A  
D4, 8—1N3756  
D5, 6—2N3228 or 2N3669 (see text)

##### CAPACITORS:

C1, 2—15 mfd, electrolytic, 50v  
C3—500 mfd, electrolytic, 15v

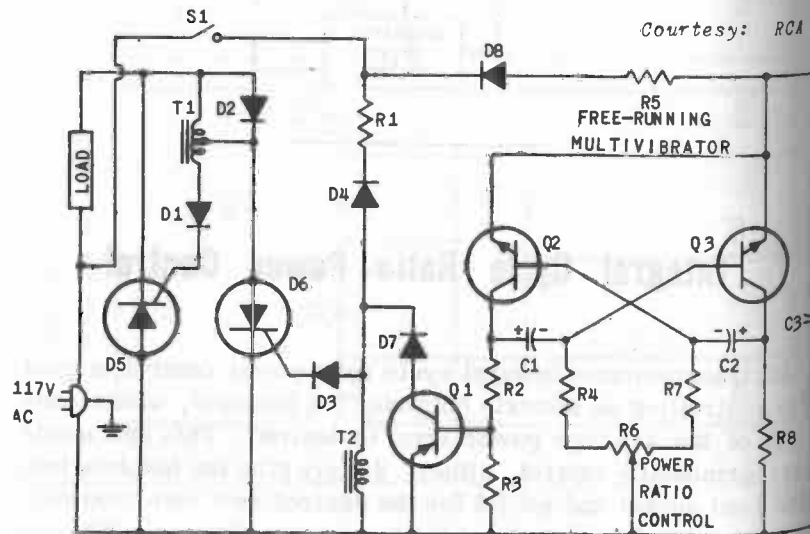
##### RESISTORS:

R1—3K, 5w

R2, 8—1K  
R3—180 ohms  
R4, 7—6.8K  
R5—2K, 5w  
R6—100K pot, linear taper

##### TRANSFORMERS:

T1—transformer (primary not used); tapped secondary used as autotransformer to provide 1-to-5 step-up in voltage; Stancor #P-6465 or equiv.  
T2—transformer (secondary not used); Stancor #P-6465 or equiv.



the emitter of Q3 through diodes D7 and D8 to the diode network which provides opposite-going pulses to the directly opposed silicon controlled rectifiers D5 and D6. These then conduct alternately, providing regulated power to the load. Operation is based on a time-sharing principal in which a portion of the output voltage, determined by the level potentiometer, is applied to the load at a given time. Maximum load is 800 watts when type 2N3228 SCRs are used, or 2000 watts when 2N3669 SCRs are used. This is not a "blinker" type device in which the output is triggered on and off for given periods. It's truly a regulator.

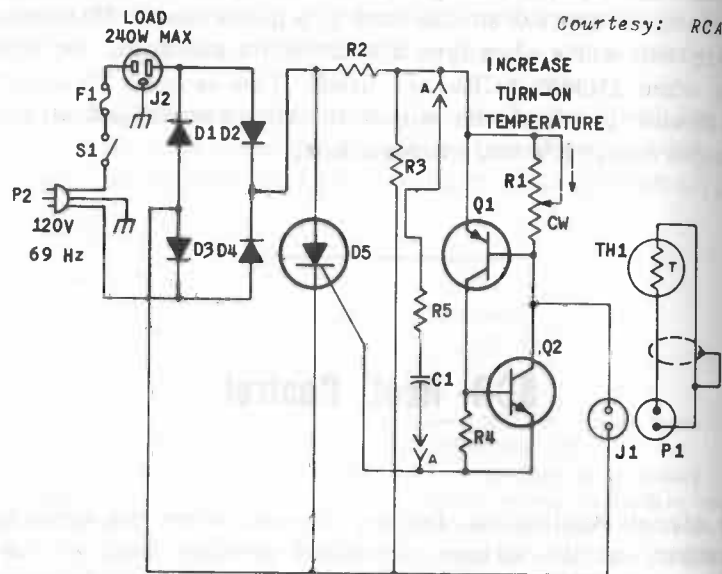
## SCR Heat Control

This circuit application further demonstrates the amazing versatility of the silicon controlled rectifier used in conjunction with other devices. Since the SCR itself is the heart of this circuit, let us depart from the usual procedure of starting at one end and working across. Instead, let's begin with the SCR itself:

The SCR is directly across the line, and you can see that with the SCR fully open the load will conduct through the 4-diode bridge rectifier. The bridge actually samples and rectifies a small portion of the current and feeds the monitoring circuit consisting of the transistors and the temperature-sensing element. The amount of regulation these components apply to the SCR gate, however, is predetermined by the setting of potentiometer R1.

In this circuit, you must first select heat-sensing element T according to the temperature range in which you are interested (shielded microphone cable is used to couple it to the control circuits). Then you have to calibrate potentiometer R1 so that you can set its dial as you would a thermostat. Again, we can cut corners by using a well-calibrated thermometer as a guide. Just make sure that the thermometer has

"settled" to an exact reading, then adjust R1 so the load goes on and off, and mark the triggering point on your dial with the temperature at which the adjustment occurs. Circuit components C1 and R5 are latching components that will, if included in the circuit, serve to keep the load in an on mode until you reset.



#### PARTS LIST

##### TRANSISTORS:

Q1—KD2101

Q2—KD2102

##### DIODES:

D1 to D4—KD2103

D5—KD2100 SCR

##### CAPACITOR:

C1—50 mfd, electrolytic, 15v,  
(see text)

##### RESISTORS:

R1—250 ohm pot, 2w linear

R2—3K, 5w

R3—180 ohms

R4—470 ohms

R5—33 ohms (see text)

##### MISCELLANEOUS:

TH1—thermistor, negative temperature coefficient, resistance variation over desired operating temperature range from 150 to 1500 ohms

F1—3 amp

J1, P1—Female and male connectors, Amphenol 80-2 or equiv.

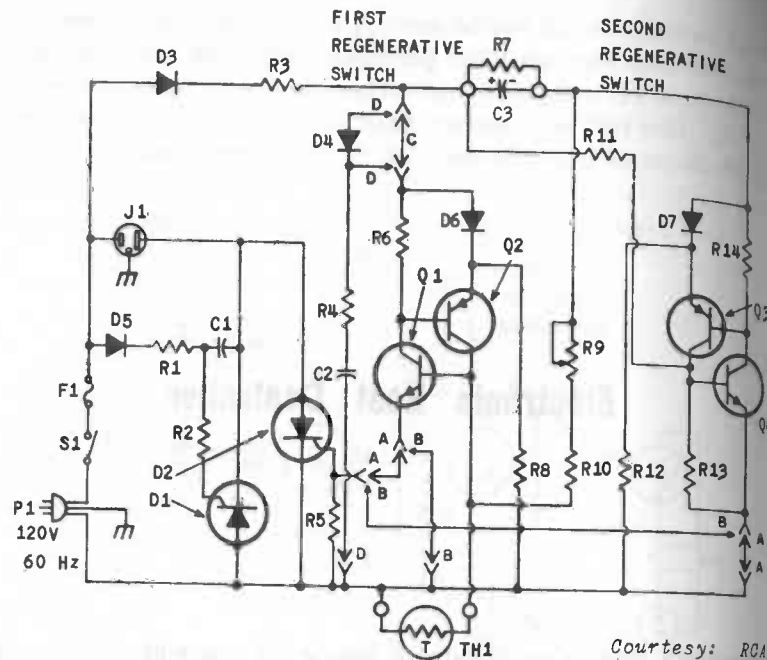
J2, P2—3-wire AC plug and receptacle

Since this circuit turns on with an increase in temperature, it makes an ideal control for an attic fan. When the temperature inside the attic rises to a preset amount, the fan automatically goes on and remains in operation until the temperature is reduced, again by a given amount.

## Electronic Heat Controller

Certainly this is an elaborate device for controlling heat, if all you plan to do is experiment in simple circuits. Elsewhere in this book, you will find circuits more appropriate to this sort of experimentation. If, on the other hand, you are employed as a designer, or are truly interested in a high-quality unit that will operate repeatedly and with good accuracy, this is for you. The interlocking circuits indicated by letters A-A, B-B, C, and D-D are to give you the option of latching or straightforward on-and-off action.

In selecting your thermistor, you have the choice of temperature range; but more important, select the type that you plan to use for your application. For example, you can obtain a thermistor in a waterproof housing for immersion in liquids. If you choose a type that is not so equipped, planning to waterproof it yourself either by potting or sealing in glass will introduce a delay in the reading, and also introduce inaccuracies that you can just as easily design around with a little care. Observe that a 3-wire grounded line cord is shown in the schematic. As heat controllers of this type are frequently used in damp atmospheres, it would be a wise move to incorporate this type of line cord in your circuit. Be sure to ground the third leg to the chassis and cabinet to avoid the hazard of electric shock.



Courtesy: RCA

#### PARTS LIST

##### TRANSISTORS:

- Q1, 4—2N2614  
Q2, 3—2N3241A

##### DIODES:

- D1, 2—2N3228 SCR  
D3—1N3737  
D4, 5, 6, 7—1N3754

##### CAPACITORS:

- C1—10 mfd, electrolytic, 15v  
C2\*—50 mfd, electrolytic, 15v  
C3—200 mfd, electrolytic, 6v

##### RESISTORS:

- R1, 3—47K, 2w  
R2—270 ohms  
R4\*—33 ohms  
R5—180 ohms  
R6, 14—150 ohms

- R7—any resistance 0 to 250 ohms  
R8, 12—22K, 0.5w  
R9—15K pot, 2w, linear taper  
R10—680 ohms  
R11—5.6K  
R13—470 ohms

##### MISCELLANEOUS:

- TH1—thermistor, negative temperature coefficient, resistance variation over desired operating temperature range from 150 to 1500 ohms  
F1—10 amp  
P1, J1—3-wire AC plug and receptacle (see text)

\*Indicates optional latching-circuit components

## IC Motor Control/Servo Amplifier

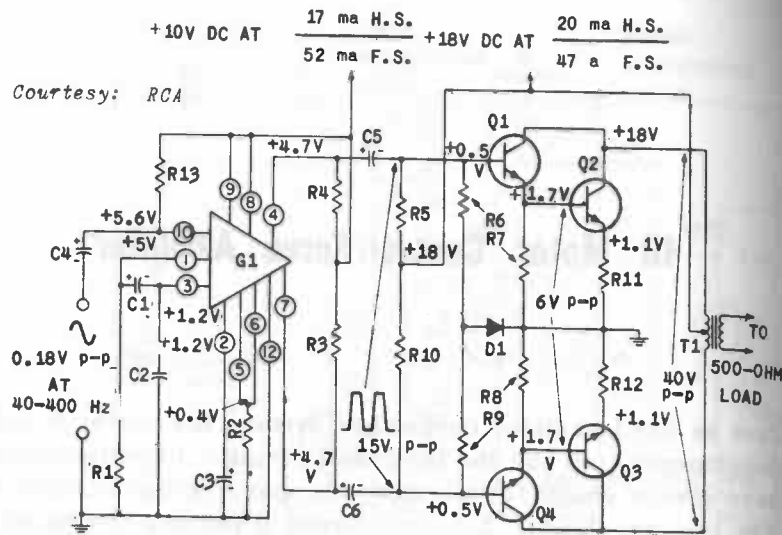
Just as the transistor opened new avenues for research and development, so has the integrated circuit. Experimenters have always sought for a better, cheaper, or more compact way to make things. In certain areas of endeavor, size and weight are of prime importance—aircraft instrumentation, for example. If you can reduce the size/weight factors of electronic equipment, you make room for additional control functions and make the aircraft safer to fly and to fly in. This is of special significance in space travel or in missile instrumentation.

When the computer came into being, its value to the aircraft industry was obvious, and to this day, pilots use data processed by computer and relayed to them in flight concerning course, altitude, etc. With the integrated circuit, however, computer size has been so vastly reduced that the pilot can have computer services in the cabin right at his fingertips, rather than depend on radio-relayed information.

Because the pilot must act on the information provided, human error is further eliminated by having the computer (and therefore the aircraft controls) directly coupled. Information from aircraft instruments is locked into the computer, and the computer is locked into the aircraft's controls. For example, take a movement such as "roll," the rotation of an aircraft on its longitudinal axis. Should a wind gust lift a wing, the pilot corrects this by adding aileron control. By computer action this is done automatically, leaving one less flight characteristic for the pilot to concern himself with.

Here is a 40- to 400-Hz motor-control circuit suitable for such action. Also, for those readers involved with servo systems, this circuit may be used as a servo amplifier.





$$\text{EFFICIENCY OF POWER STAGE AT 80-400 Hz} = \frac{29 \times 100}{85} = 34\%$$

$$\text{EFFICIENCY OF POWER STAGE AT 40 Hz} = \frac{21 \times 100}{85} = 25\%$$

#### PARTS LIST

##### TRANSISTORS:

Q1, 4—2N3053  
Q2, 3—2N3772

##### IC:

G1—CA3020

##### DIODE:

D1—1N1763A

##### CAPACITORS:

C1, 3, 4, 5, 6—100 mfd, elec-trolytic, 10v

C2—.1 mfd

##### RESISTORS:

R1—4.7K, 1w  
R2—5 ohms, 1w  
R3, 4—270 ohms, 1w  
R5, 10—22K, 1w  
R6, 7, 8, 9—470 ohms, 1w  
R11, 12—.5 ohm, 10w  
R13—470K, 1w

##### TRANSFORMER:

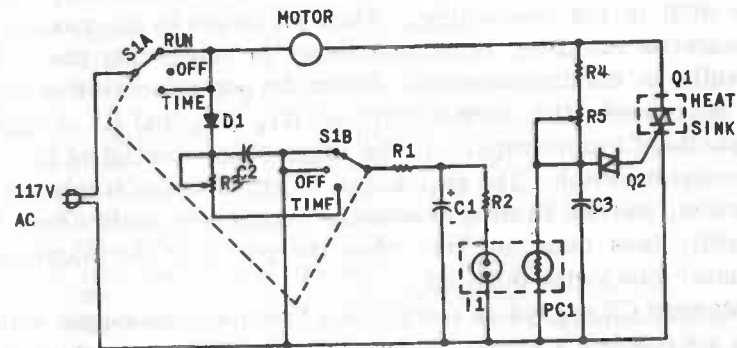
T1—Stancor P-8358, 120v RMS, 0.245 amp, 29w at 80 to 400 Hz

## Thyristor/Photocell Timer

It's an interesting point that many solid-state junctions will act as photoelectric sensors. While this circuit actually employs a standard photocell, others have simply used uncased transistors, so that light could fall on the junction and activate

it. A moment spent in studying this circuit will probably nurture some other ideas. For example, by using only the photoelectric components and ignoring the neon lamp circuits you can make any small size motor react to any light—from a small flashlight, for instance. To make the photocell function as a light-actuated switch, mount it inside a deep black-painted tube, so that stray or ambient light will not activate it.

If you own a blender, you are aware that a timer for this appliance can be a handy adjunct. Mount the neon lamp and photocell in such a way that only the light from the neon lamp can fall on the photocell. With the switch in the off position, the blender will not run. In the time position, the blender runs as usual, but the 100K resistor and the 100-mfd capacitor charge. When the capacitor is charged to the firing point of the neon lamp, it lights, activating the photocell. This dumps the capacitor into the trigger circuit, keeping it from recharging, and stopping the motor.



Courtesy: RCA

#### PARTS LIST

##### TRANSISTORS:

Q1—T1C21  
Q2—T143

##### PHOTOCELL:

PC1—Amperex B873107 (see text)

##### DIODE:

D1—1N2070

##### CAPACITORS:

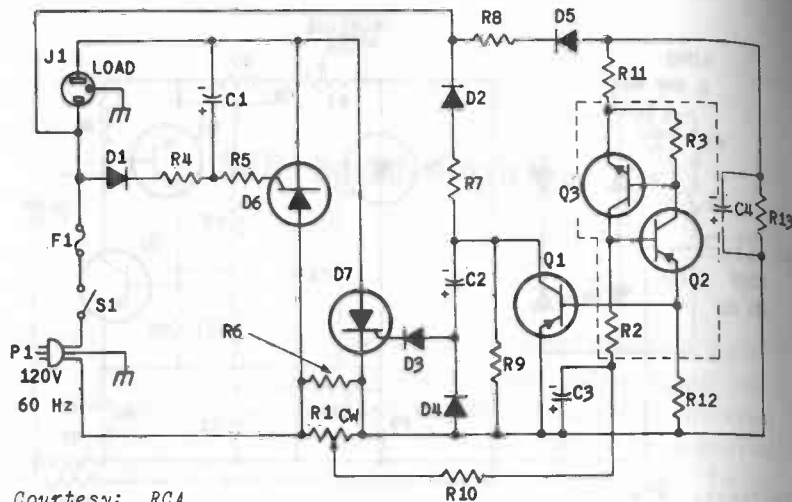
C1—100 mfd, electrolytic, 150v  
C2—.1 mfd, 300v

C3—.033 mfd

##### RESISTORS:

R1—10K  
R2—100K  
R3—100K pot, semi-log taper  
R4—33K  
R5—500K pot  
MISCELLANEOUS:  
I1—NE-2H (see text)





Courtesy: RCA

### PARTS LIST

#### TRANSISTORS:

Q1, 2—KD2101

Q3—KD2102

#### DIODES:

D1 to D5—KD2103

D6, 7—KD2100 SCR

#### CAPACITORS:

C1, 2, 3—10 mfd, electrolytic, 15v

C4—100 mfd, electrolytic, 12v

#### RESISTORS:

R1—50-ohm pot, 2w linear

R2, 10—150 ohms

R3, 9, 11—470 ohms

R4, 7—4.7K, 2w

R5—270 ohms

R6—.165 ohms (see text)

R8—6.8K, 2w

R12—1K

R13—1.5K

#### MISCELLANEOUS:

F1—10 amp

P1, J1—3-wire AC plug and receptacle

by reading excessive current drawn through the line. It turns off the power to the drill before trouble can occur.

Here's how it works: When switch S1 is closed, C2 is charged through R7 and D2 and D4 when the diodes are forward-biased by the power source. On the following half-cycle, the charge on C2 is triggers the gate of SCR D7. The voltage placed across the load during this half cycle is also applied to the combination of D1, R4, and C1, causing C1 to charge. The residual charge on this capacitor triggers SCR D6 during the next half-cycle. This process continues to repeat as long as transistor Q1 is not conducting, which is to say when no overload condition is sensed.

When current drawn by the load causes the regenerative switch to conduct, an overload condition is present. The

potential at which this switch will conduct is set by the potentiometer. R1 in combination with R6 forms a sensing resistance that detects increasing current to the load. When this current is high enough to make Q2's base negative with respect to its emitter, the switch conducts. The voltage across the switch is derived from C4, which is charged through R8 and D5 by the power source. When the switch conducts, it turns on Q1 by making its base more negative with respect to its emitter. When Q1 conducts, the charging path for C2 is bypassed.

Resistor R6 is homemade by winding 10 feet of #22 wire noninductively. Scramble-wind this on any convenient form.

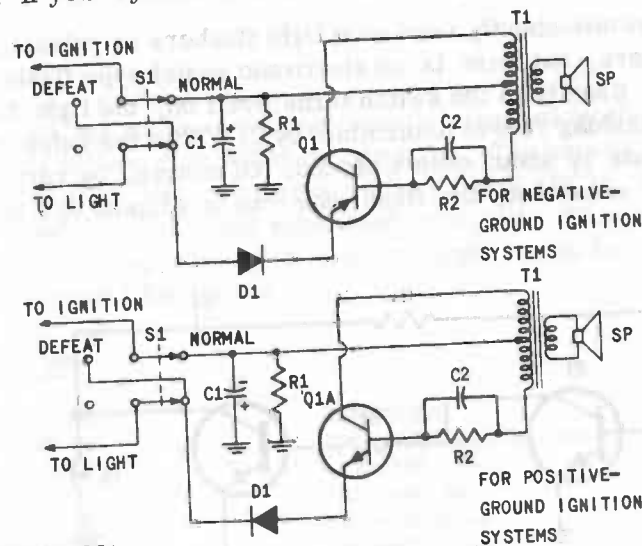
## LIGHT CONTROLLING CIRCUITS

### Car Light Minder

This circuit actually performs somewhat like a NOR gate used in computers. It senses the presence of two conditions. The ignition key must be on and the car lights must be on, or the ignition key must be off and the car lights off. If the ignition key is turned off with the lights still on, the change in the direction of current flow is sensed by D1, thus triggering Q1 into oscillation. S1 provides a defeat position, because there are times when you will want the lights on and the ignition off. This circuit may be used also to detect undesired conditions in other circumstances where operating voltages are similar. Or it may be modified to suit many automated industrial amplifications where the operation of one device is vital to the correct performance of another.

You will notice that two separate schematics are provided here, one for negative and the other positive battery grounds. To ascertain which system is in use in your own automobile, open the hood and look at the battery. One of the battery posts will be marked with a minus sign, or the letters NEG. The

other will have a plus sign, or the letters POS. The ground connection is generally made with a heavy piece of braided wire, usually uninsulated. As a further check, the positive terminal, or "hot" side, will have a length of heavily insulated wire connected to the horn, the starter motor, etc. From these connections, you can tell which side is grounded. If you have a negative grounded system, use the upper diagram. If your system is positive ground, use the lower one.



Courtesy: RCA

#### PARTS LIST

##### TRANSISTOR:

Q1—2N217

Q1A—2N647

##### DIODE:

D1—1N34 (observe polarity)

##### CAPACITORS:

C1—0.22 mfd electrolytic, 25v

C2—30 mfd, 15v

##### RESISTORS:

R1—15K

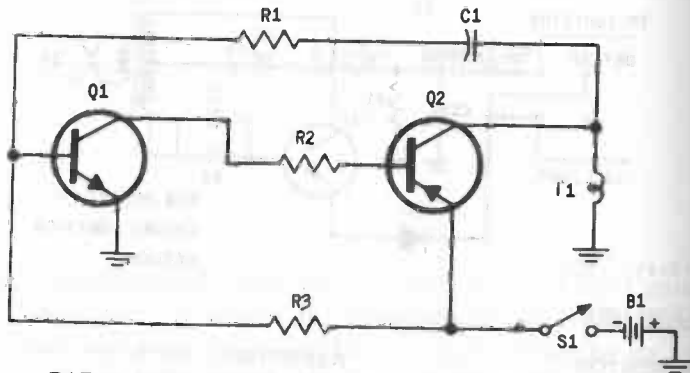
R2—680 ohms

##### TRANSFORMER:

T1—audio-output transformer; 400-ohm primary, 11-ohm secondary; Lafayette #99R6209 or equiv.

## Light Flasher

You've undoubtedly seen neon light flashers or relaxation oscillators, but here is an electronic switch type flasher circuit. Each time the switch turns itself on, the light flashes. The flashing rate is determined by C1. With the value shown, the rate is about once a second. Of course, by varying the value somewhat, the flash rate can be adapted to a specific need.



### PARTS LIST

#### TRANSISTORS:

Q1—2N438A

Q2—2N565

#### CAPACITOR:

C1—3 mfd electrolytic, 15v

#### RESISTORS:

R1—100 ohms

R2—1K

R3—820K

#### BATTERY:

B1—6v

#### MISCELLANEOUS:

I1—#47 lamp

Courtesy: Radio Shack

The circuit would make a handy signal for the car or boat. Or if you want to have fun with your friends, mount the components in a metal box so they can't see the accompanying circuitry. They'll wonder how you built a flasher with an incandescent lamp! Current drain is very light, so a set of batteries should last a long time.

## SCR Light Switch

Q1 and Q4 act as an electronic switch triggered by the conduction of silicon controlled rectifier D5. The sensor which drives the SCR into conduction is the KD2106 (PC1), shown here wired remotely and connected by J1-P1. This circuit is designed to operate when ambient light levels fall below predetermined illumination.

### PARTS LIST

#### TRANSISTORS:

Q1—KD2101

Q2—KD2102

#### DIODES:

D1 to D4 —KD2103

D5—KD2100 SCR

D6—KD2104

#### PHOTOCELL:

PC1—KD2106

#### CAPACITORS:

C1—50 mfd electrolytic, 150v

C2—50 mfd electrolytic, 15v (see text)

#### RESISTORS:

R1—2.5K pot, 2w linear

R2—25K, 1w

R3—3K, 5w

R4—150 ohms

R5—470 ohms

R6—33 ohms (see text)

#### MISCELLANEOUS:

P1, J1—Amphenol 80-2 plug and jack

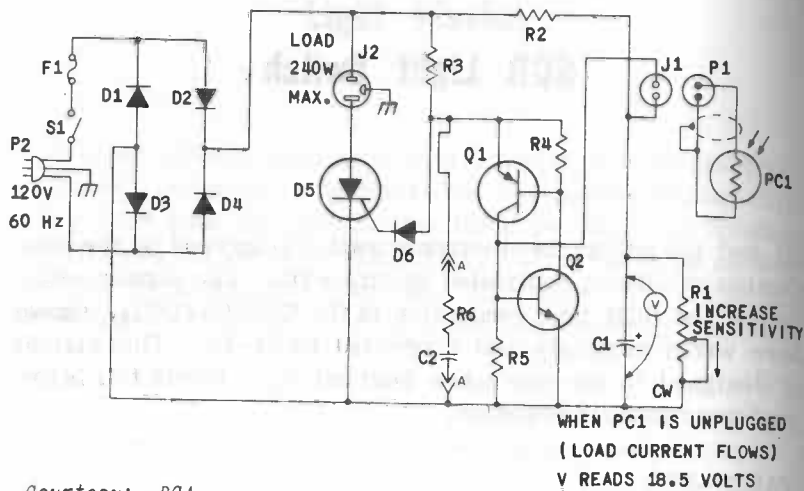
P2, J2—3-wire AC plug and receptacle

F1—3 amp fuse

To set up the unit, place the sensor so it faces a window, and plug a lamp into the load socket. When evening falls, and the ambient light levels are such that you would want the lamp to turn on, adjust potentiometer R1 until the lamp lights. In the morning, notice that the increased ambient light has caused the lamp to turn off. If it has not, readjust R1 until the lamp does go off, and then recheck the following night to see that the lamp comes on again.

To use the circuit in this fashion, omit the network compromised by R6 and C2, which function in a latching mode to keep the light on once the circuit has been triggered into the

on condition. If you have applications where you would want an instantaneous light source to keep the light off, then include these components.



Courtesy: RCA

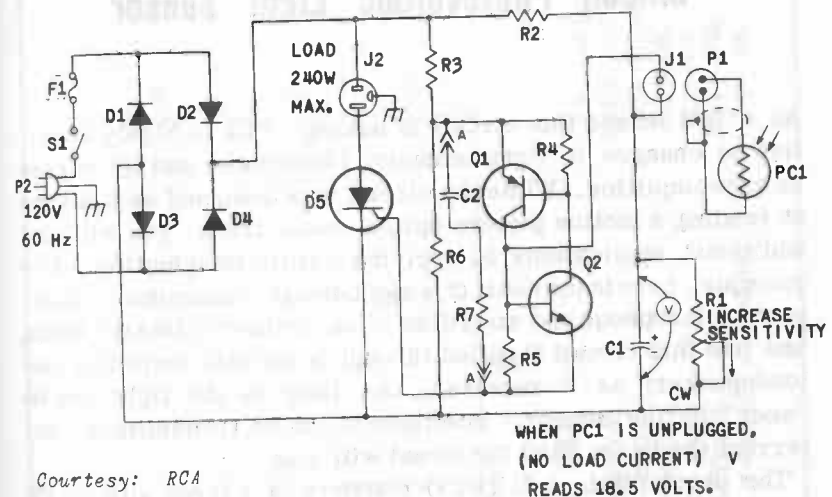
## Light-Activated Switch

This circuit provides a control that turns a lamp on with an increase in light on the sensor. Applications? How about a garage light that automatically goes on when automobile headlights hit the sensor? Or a dock light for a boat that can be turned on when a flashlight is played on it from the deck? To avoid triggering by ambient light during the day, the sensor should be mounted deeply in a flat black-painted tube.

The light level at which this circuit applies power to the load is adjusted by potentiometer R1. When switch S1 is closed, rectified current from the KD2103 bridge charges C1 to a potential determined by the setting of potentiometer R1. R1, R2, and C1 act as a power source for photocell KD2106. R1 should be set so the ambient light won't charge C1 to a level that will trigger the 2-stage electronic switch. As in-

cident light on the photocell increases, its resistance goes down, and the increased current through the photocell, R5, and the gate-cathode path of the silicon controlled rectifier will trigger the switch. When the switch becomes saturated, current through R3 is applied to the gate of the SCR, and it is triggered into conduction. This completes the load circuit. Voltage divider R3 and R6 keeps the potential across the switch within limits when it is not conducting. References here are, of course, to the transistor switch formed by Q1 and Q2.

As long as light remains above the required level, the switch is retriggered early in each AC input half-cycle by means of the current from C1, and the SCR, in turn, is retriggered.



Courtesy: RCA

### PARTS LIST

#### TRANSISTORS:

Q1—KD2101  
Q2—KD2102

#### DIODES:

D1 to D4—KD2103  
D5—KD2100

#### PHOTOCELL:

PC1—KD2106

#### CAPACITORS:

C1—50 mfd electrolytic, 150v  
C2—50 mfd electrolytic, 15v,  
(see text)

#### RESISTORS:

R1—2.5K pot, 2w linear  
R2—25K, 1w  
R3—3K, 5w  
R4—150 ohms  
R5—470 ohms  
R6—180 ohms  
R7—33 ohms (see text)

#### MISCELLANEOUS:

P1, J1—Amphenol 80-2 plug and connector  
P2, J2—3-wire AC plug and receptacle  
F1—3 amp fuse

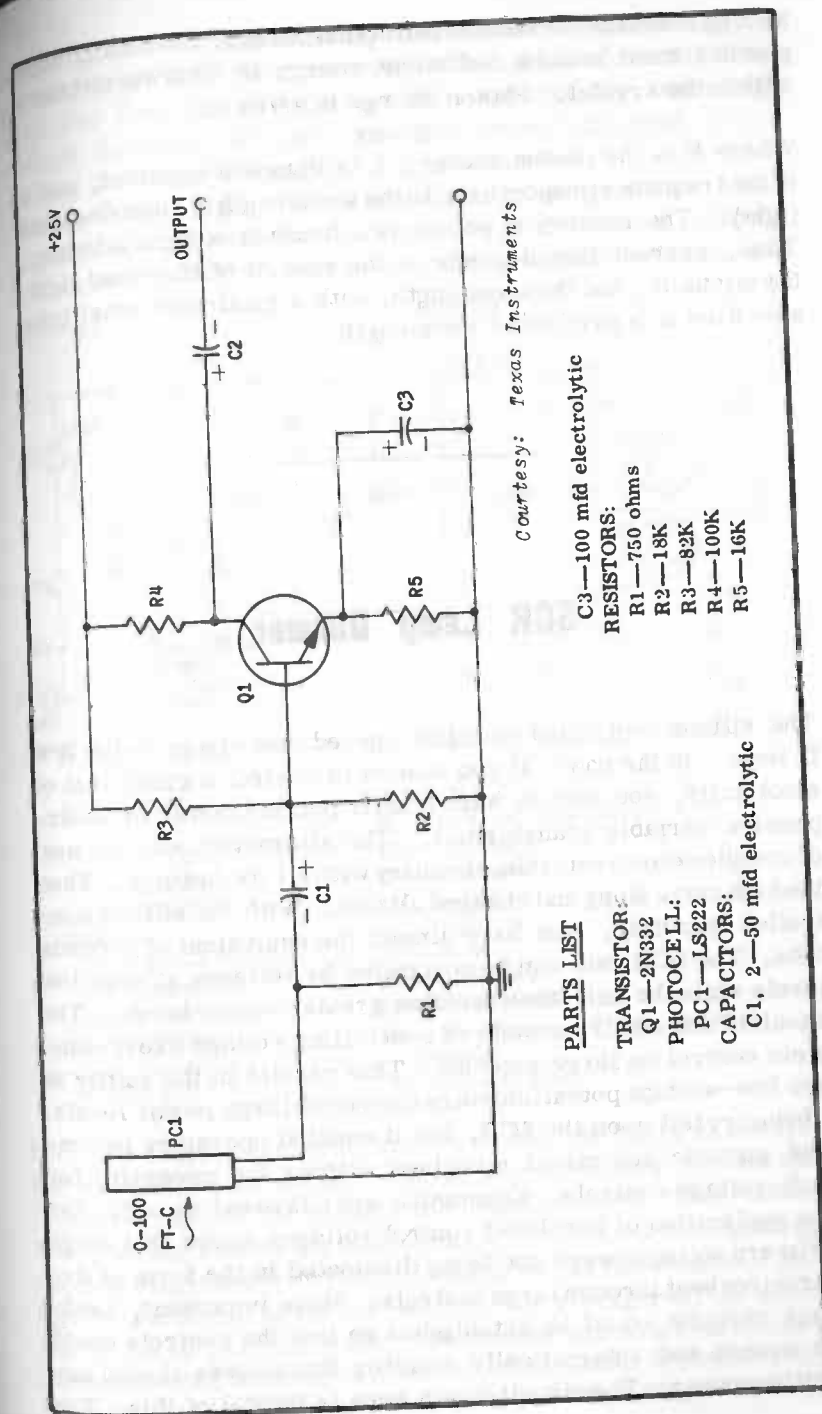
When the light falls below the minimum required level, the resistance of PC1 increases, the current from capacitor C1 drops below the triggering value, and the switch opens. The circuitry formed by C2 and R7, shown from "A" to "A" on the diagram, will keep the circuit latched (keeps the load on) even after light falls below triggering level.

## Silicon Photovoltaic Light Sensor

As a light sensor this circuit is unique. PC1 is highly sensitive to changes in light intensity (amplitude) and Q1 serves as a preamplifier. While the circuit was designed as a means of reading a motion picture optical sound track, you will find additional applications by applying a little imagination. For example, here is the heart of a light-beam transmitter. Connect a microphone and amplifier to an ordinary electric lamp, and use this circuit (applied through a suitable amplifier and loudspeaker) as a receiver. As long as the light can be "seen" by the sensor, intelligence can be transmitted. Interrupt the beam, and the sound will stop.

The photovoltaic cell (PC1) consists of a large silicon PN junction which is exposed to incident light energy. Impinging photons having sufficient energy break a valence bond within the junction area and create an electron-hole pair. The current flow thus generated is directly proportional to the number of electron-hole pairs created, the intensity of the incident light, and the junction area. Two electrical contacts are provided so this current may be applied to a load. The voltage developed is a complex function of light intensity.

The ability of impinging light to create an electron-hole pair within the silicon crystal depends on several factors. First, the light must penetrate and be absorbed by the crystal. Since any reflected or transmitted light causes an overall drop in cell efficiency, the active surface of the cell is coated with



Courtesy: Texas Instruments

C3—100 mfd electrolytic

RESISTORS:

R1—750 ohms

R2—18K

R3—82K

R4—100K

R5—16K

PARTS LIST

TRANSISTOR:

Q1—2N332

PHOTOCELL:

PC1—LS222

CAPACITORS:

C1, 2—50 mfd electrolytic

silicon monoxide to reduce reflection losses. Secondly, light photons must contain sufficient energy to liberate carriers within the crystal. Photon energy is given as:

$$E = hv$$

Where E is the photon energy, h is Planck's constant, and v is the frequency proportional to the wavelength of light (incident light). The number of photos is a function of light intensity. Thus, current flow depends on the amount of absorbed light, the intensity, and the wavelength, with a maximum sensitivity specified at a particular wavelength.

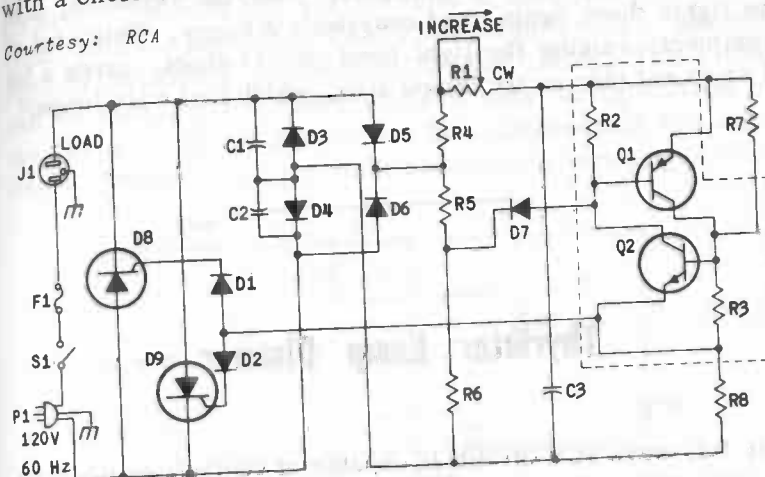
## SCR Lamp Dimmer

The silicon controlled rectifier opened new vistas to the R & D boys. In the past, if you wanted to control a great deal of electricity, you had to have a hefty potentiometer or an expensive variable transformer. The alternative was the use of complex electronic tube circuitry with all its failings. Then the SCR came along and changed all that. With the silicon controlled rectifier, you have almost the equivalent of a triode tube. The SCR gate can be controlled by voltages at very low levels while the unit itself handles greater power levels. The result is that small amounts of controlling voltage exert complete control on large amounts. This results in the ability to use low-wattage potentiometers to control large power levels.

Industry fell upon the SCR, for it enabled operators to control gigantic automated machines without the necessity for high-voltage controls. Economics were favored as well, for the application of low-level control voltages meant that large primary voltages were not being dissipated in the form of destructive heat through large controls. More important, feedback circuits could be established so that the controls could be preset and automatically monitor themselves should any drifting occur. The circuit shown here is typical of this: The

load level (240 watts maximum) is established by the setting of potentiometer R1. Control over both halves of the AC sine wave are fixed by SCR D8 and D9. Q1 and Q2, operating through the diode network, monitor the voltage level, preserving the output setting in spite of deviation. As a means of light control in the photographic studio, this circuit offers several advantages. The studio photog is faced with a choice. He can set his lighting for a good average and

Courtesy: RCA



### PARTS LIST

#### TRANSISTORS:

Q1—KD2101

Q2—KD2102

#### DIODES:

D1 to D6—KD2103

D7—KD2104

D8, 9—KD2100

#### CAPACITORS:

C1, 2—.01 mfd, 1kv

C3—1 mfd

#### RESISTORS:

R1—100K pot, 2w linear

R2—150 ohms

R3—470 ohms

R4, 6—1K

R5—15K, 1w

R7—5.6K

R8—100 ohms

#### MISCELLANEOUS:

P1, J1—3-wire AC plug and receptacle

F1—10 amp fuse

keep his fingers crossed, or he can reset his lights as needed for each different subject. Most photographers prefer the latter course, as the results are usually better. This, however, means making the model bake while you set the lighting, check the lightmeter and the viewing glass in the camera, and then set the lights again. If the model is paying you, as when you're doing portrait work, you can bet you won't have customers coming back again. On the other hand, if you're paying the model (and this can sometimes go to \$25.00 per hour!),



by the time you get the lights all set, your model isn't worth 25¢ per hour. She's perspired, makeup is running, and hair is stringy.

To get around these problems, the author uses this sort of light dimmer. With the lighting reduced, models are always comfortable, and you have sufficient light to set the camera properly. Then when you're ready to shoot, you close down the diaphragm, open up the lights, make the exposure, dim the lights down again, and everybody's happy. This kind of treatment, raising the light level only to shoot, saves a lot of wear and tear on the lamps also, which last a lot longer!

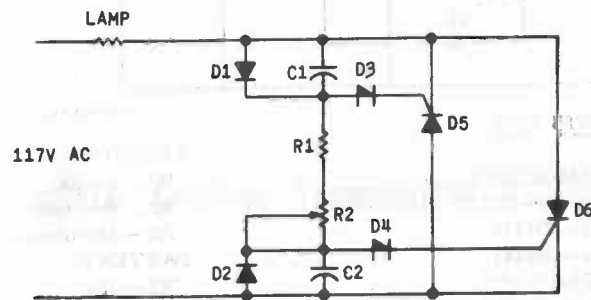
## Thyristor Lamp Dimmer

This full-wave SCR circuit is capable of controlling loads up to 1000 watts. In the past, the control of such power levels required bulky and relatively ineffective devices such as huge rheostats and transformers of various types. They have largely been replaced by solid-state components which, due to their relatively low power-handling capabilities, were limited to the control of voltages at very low levels. However, high-voltage, high-power thyristors have been slowly changing the general complexion of all this. "Thyristor" is a family name for a group of devices. Two of these are the unilateral thyristor, or SCR, and the bilateral thyristor, variously known as the Triac, Quadrac, or Bilat.

SCR conduction is triggered by a positive voltage applied to the gate of the device. While conducting it behaves like a rectifier, allowing current flow in one direction only. The Triac has the advantage that it can be triggered by a gate-to-anode voltage of any polarity. Then it can conduct current in either direction. The gate of a thyristor exhibits a nonlinear low-impedance, similar to the forward drop of a diode. So it is necessary for a thyristor to be driven by a low-impedance source. In other words, the thyristor is current-sensitive

rather than voltage-sensitive and may require, especially in the case of Triacs, over 100 ma for at least a few uses.

To provide this short-term current, a capacitor is usually connected to the gate. This requires a low-power on-off switch. Two devices, the unijunction transistor and the trigger diode, were developed for this purpose. In the circuit shown, the conduction angle can be varied from approximately 20 to 174° on each half-cycle. Most of the parts are not critical, with the exception of the 250K potentiometer, matched phasing capacitors, and matched trigger diodes. This circuit can be modified for lower loads by substituting a TIC30 for the TI40A4, and the unit will handle a maximum of 700 watts. Use a 2N685A, and you can increase the wattage to 4000.



Courtesy: Texas Instruments

### PARTS LIST

#### DIODES:

D1, 2—1N2069  
D3, 4—TI42  
D5, 6—TI40A4

#### CAPACITORS:

C1, 2—.1 mfd

#### RESISTORS:

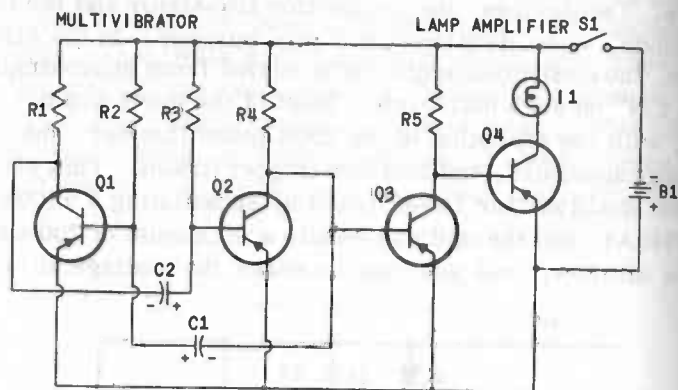
R1—1K  
R2—250K pot

## Variable Rate Flasher

This circuit operates at about 60 flashes per minute. The lamp is an integral part of the circuit and is a 12v, 1 amp type. Changing the values of C1 and C2 will vary the flashing rate.

With a fixed flashing rate of 60 per minute, it makes an excellent timer. Of course, there are applications where you

will not want a light, such as in a photographic darkroom, and would prefer to have an audible indicator. You can use any non-inductive device to replace the lamp—for example, one of the new electronic beepers.



#### PARTS LIST

##### TRANSISTORS:

Q1, 2—2N217  
Q3—2N270  
Q4—2N441

##### CAPACITORS:

C1—25 mfd electrolytic, 12v  
C2—100 mfd electrolytic, 12v

##### RESISTORS:

R1, 4—2K  
R2, 3—100K  
R5—120 ohms

##### BATTERY:

B1—12v

##### MISCELLANEOUS:

I1—12v, 1 amp

Courtesy: RCA

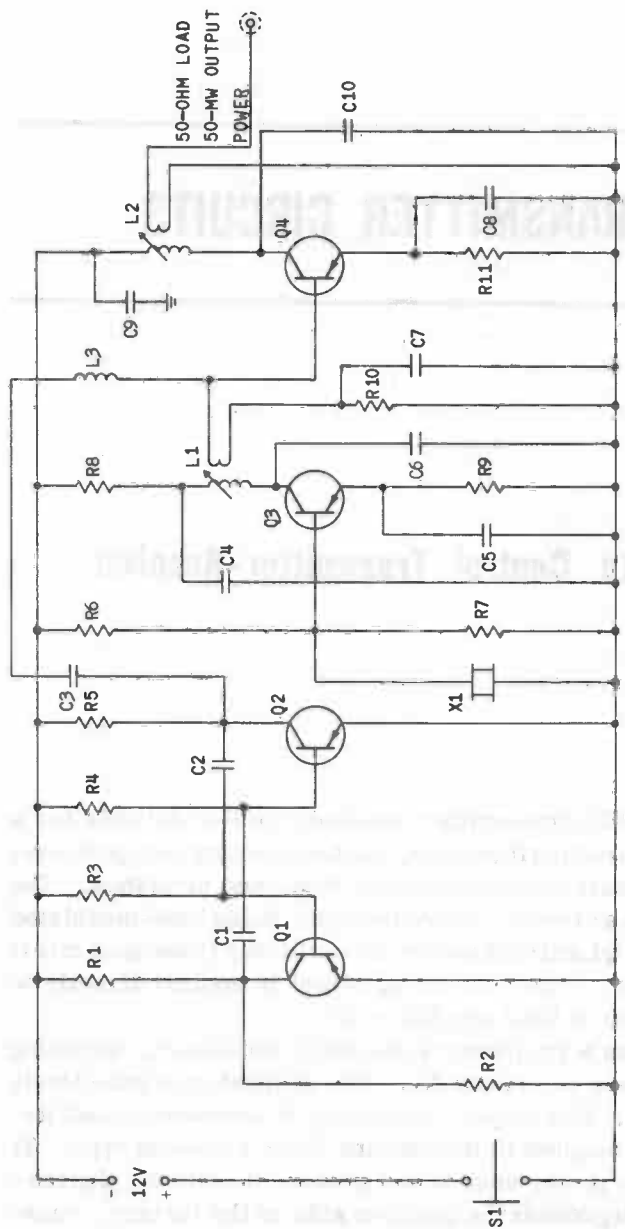
## TRANSMITTER CIRCUITS

### Remote Control Transmitter-Receiver

Here is a 27-MHz transmitter-receiver system suitable for a number of controlling functions, such as opening garage doors, and applying basic controls to model boats and airplanes. The transmitter is a crystal-controlled type, using tone-modulated frequencies. Q1 and Q2 function as oscillator (tone generator) and modulator. The modulating signal is applied directly to the input (base) of final amplifier Q4.

Q3 serves as a frequency-generating oscillator, operating at the frequency of crystal X1. The oscillator is inductively coupled to Q4. The output, consisting of tone-modulated RF, is inductively coupled to the antenna jack, a coaxial type. S1 is between the power source and ground; therefore, depressing the switch grounds the positive side of the battery, causing all circuits to operate.

The receiver shown is a direct-coupled regenerative type. The antenna signal is applied to the collector of Q1 via antenna



Courtesy: Texas Instruments

**COILS:**

L1, 2—Adjustable RF coil (J. W. Miller #4403 or equiv.) Add 2 turns of #24 enameled wire on cold end.  
 L3—RFC, 15  $\mu$ h (Delevan #1537-40 or equiv.)

**RESISTORS:**

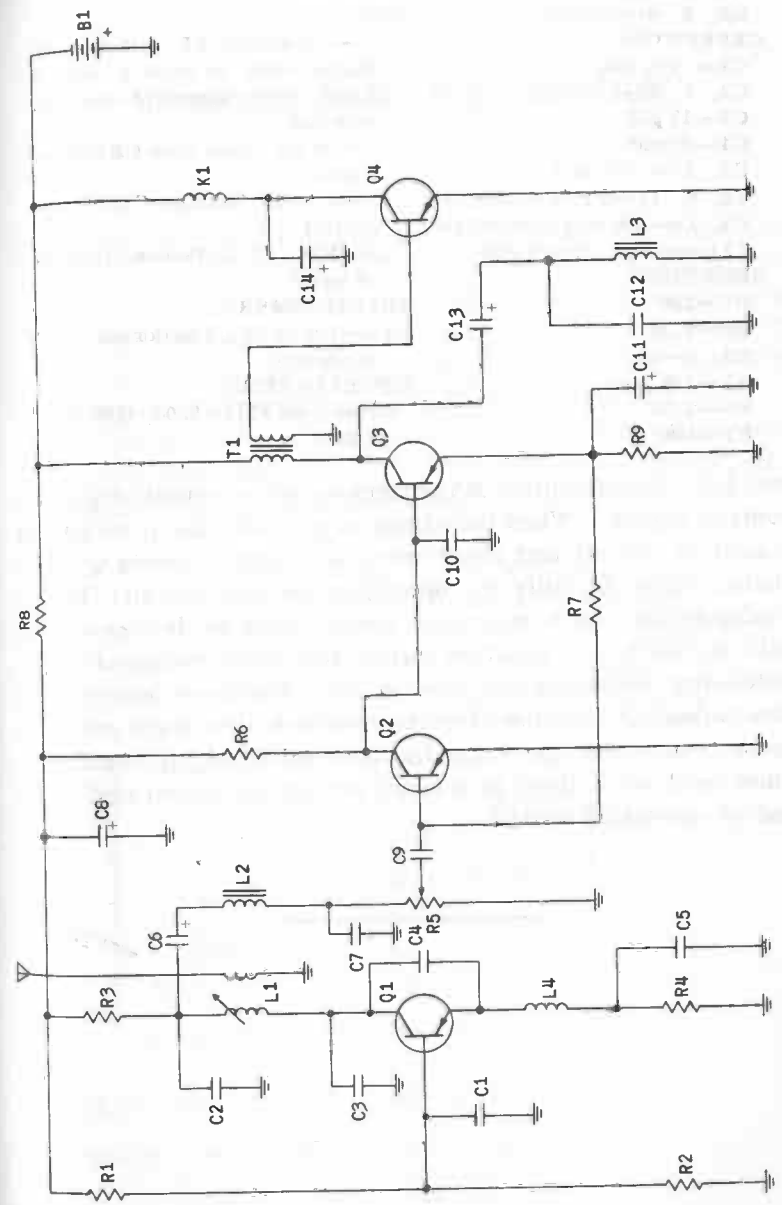
R8, 9—150 ohms  
 R10—1K  
 R11—47 ohms  
 CRYSTAL  
 X1—27.255-MHZ

**CAPACITORS:**

C1, 2—.01 mfd  
 C3—.1 mfd  
 C4, 7, 8, 9—.05 mfd  
 C5—56 pfd  
 C6, 10—33 pfd

**PARTS LIST TRANSMITTER**

**TRANSISTORS:**  
 Q1, 2—2N1274  
 Q3, 4—1V1395



Courtesy: Texas Instruments

## PARTS LIST RECEIVER

### TRANSISTORS:

Q1—2N2188  
Q2, 3, 4—2N1274

### CAPACITORS:

C1—.001 mfd  
C2, 7, 10—.05 mfd  
C3—15 pfd  
C4—18 pfd  
C5, 12—.002 mfd  
C6, 9, 13—5 mfd electrolytic  
C8, 14—100 mfd electrolytic  
C11—40 mfd electrolytic

### RESISTORS:

R1—22K  
R2—2.2K  
R3, 4—1K  
R5—10K pot  
R6—2.7K  
R7—10K

R8—270 ohms

R9—150 ohms

### BATTERY:

B1—12v

### COILS:

L1—Adjustable RF coil (J. W. Miller #4403 or equiv.). Add 2 turns of #24 enameled wire on cold end.

L2—30 mh choke (Bud CH1227 or equiv.)

L3—8.5 hy (Stancor C1279 or equiv.)

L4—RFC, 15  $\mu$ h (Delevan 1537-44 or equiv.)

### TRANSFORMER:

T1—10K to 2K (Thordorson TR7 or equiv.)

### MISCELLANEOUS:

K1—Sigma #11F-2300-G/SIL or equiv.

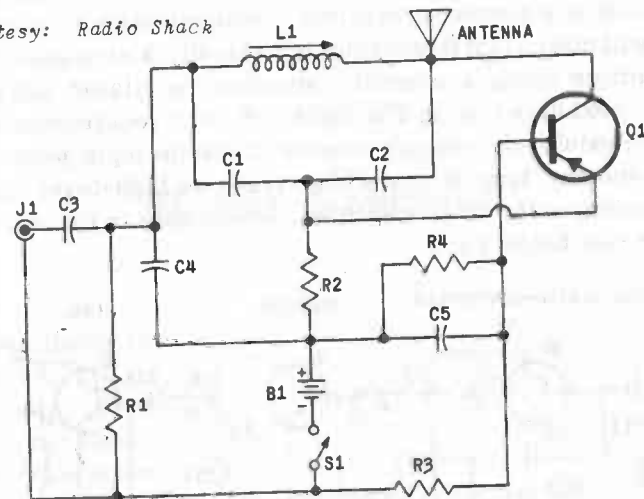
coil L1. Level control R5 adjusts receiver sensitivity to the control signal. When the signal is present, Q4 is no longer biased to cut-off and commences to conduct. When Q4 conducts, relay K1 pulls in, operating the load circuit. In this configuration the transmitter button must be depressed and held in the active position during the entire required cycle. Releasing the button will prevent the action from operating to conclusion. A latching circuit could be built around relay K1 so that once the operation has been initiated, it would continue until such time as a reset circuit were operated by an end-of-operation switch.

## Broadcast Band Mini-Transistor

Any broadcast-band receiver will pick up the signal radiated by this circuit. A single 2N321 transistor operates as a tuned-circuit oscillator, whose frequency may be adjusted by L1 to any point between 550 and 1600 kHz. L1, C1, and C2 determine the operating frequency. To comply with FCC regulations, the antenna must be kept under 10 feet long.

The desired input is introduced at J1. Ceramic or crystal phono cartridge output is sufficient to drive the circuit, or a crystal or ceramic microphone may be used, too.

Courtesy: Radio Shack



### PARTS LIST

#### TRANSISTOR:

Q1—2N321

#### CAPACITORS:

C1, 2—75 pfd ceramic  
C3—.05 mfd  
C4, 5—.02 mfd

#### RESISTORS:

R1, 2, 3—10K  
R4—4.3K

#### BATTERY:

B1—3v

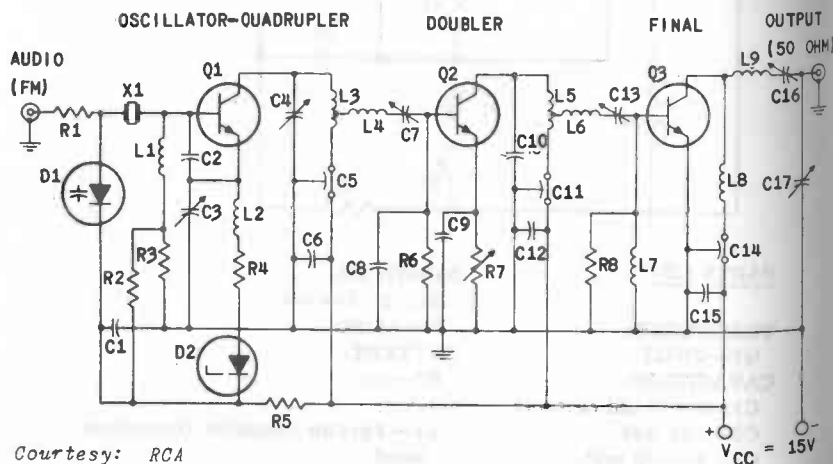
#### COIL:

L1—Ferrite loopstick (broadcast band)

## Sonobuoy Transmitter

Sonobuoys are anti-submarine warfare (ASW) devices used by the Navy. They are dropped from aircraft, float on the surface, and transmit signals from submarines to the airplane above. Three sonobuoys are usually dropped in a suspect area, and by triangulation the submarine is located. If the sub is found, additional buoys are dropped to help plot its course. Well, maybe you aren't trying to locate submarines, but with this circuit as a guide, it seems that some really heads-up electronic-type scuba divers ought to be able to devise a way to use this as a means of wireless communication with a boat.

You will notice that this circuit is basically a straightforward transmitter using a crystal-controlled oscillator and quadrupler modulated by an FM input. If your requirements call for AM modulation, simply remove R1 and the input jack; then, apply another type of modulation (such as high-level Heising modulation) at the final amplifier, preferably in the collector circuit just below L8.



Courtesy: RCA

## PARTS LIST

### TRANSISTORS:

- Q1—2N3866
- Q2—2N3553
- Q3—TA2711

### DIODES:

- D1—Varactor
- D2—12v Zener

### CAPACITORS:

- C1—0.05 mfd
- C2—75 pfd
- C3—32-250 pfd
- C4, 10, 16, 17—3-35 pfd
- C5—2300 pfd, feedthrough
- C6, 12, 15—0.01 mfd
- C7—14-150 pfd
- C8—50 pfd
- C9—500 pfd
- C11, 14—1500 pfd, feedthrough
- C13—8-60 pfd

### RESISTORS:

- R1—1K

- R2—1.2K
- R3—47 ohms
- R4—10 ohms
- R5, 8—100 ohms
- R6—51 ohms
- R7—50 ohm pot

### COILS:

- L1—22  $\mu$ h
- L2—5.5  $\mu$ h
- L3—3 turns #16 wire, 1/4" ID x 1/2" L
- L4—5 turns #22 wire, 3/16" ID (close wound)
- L5—2 1/4 turns #16 wire, 1/4" ID x 3/8" L
- L6—2 1/4 turns #18 wire, 7/32" ID (close wound)
- L7, 8—1.0  $\mu$ h
- L9—5 turns #16 wire, 1/4" ID x 3/8" L

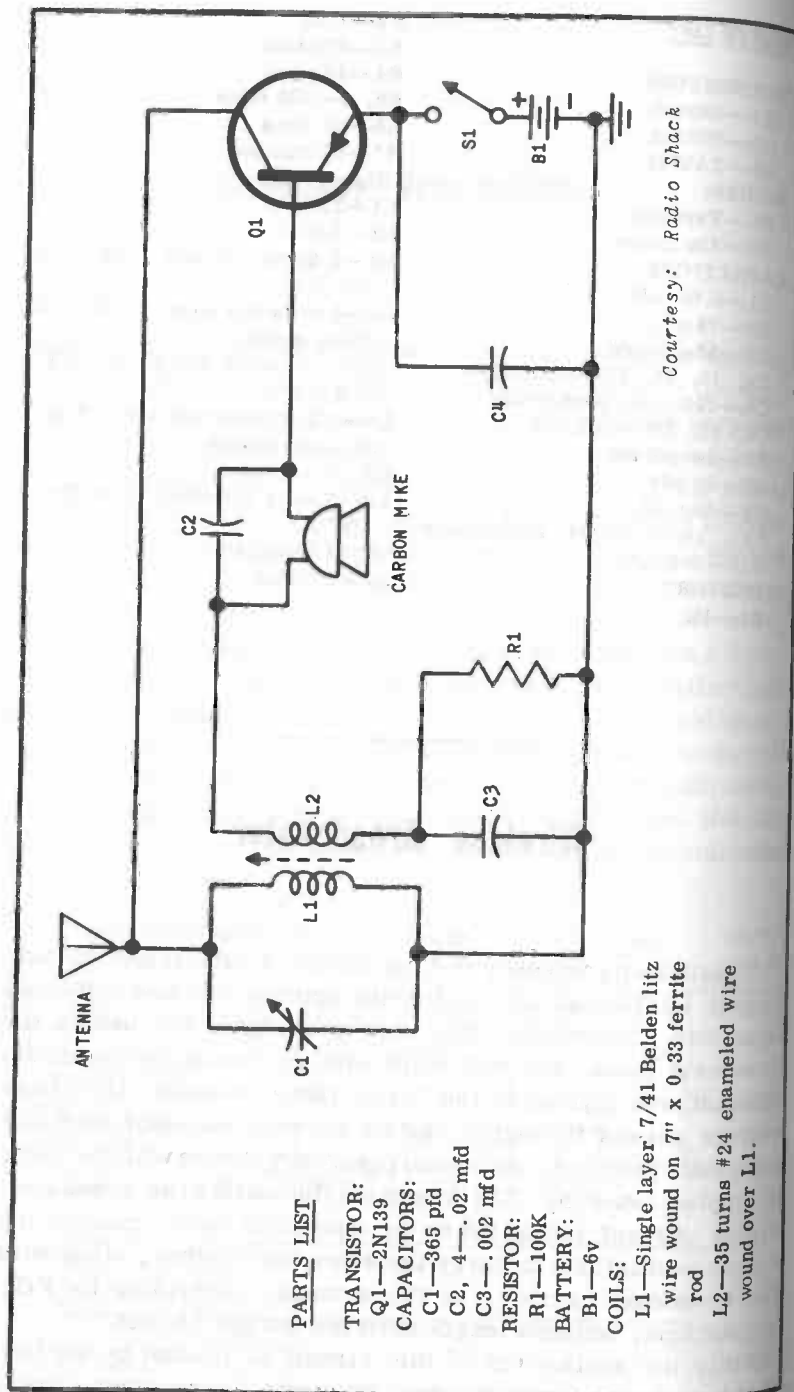
### MISCELLANEOUS:

- X1—Crystal

## Wireless Broadcaster

The oscillator frequency in this circuit is determined by tank circuit L1/L2 and C1—a ferrite antenna coil and a 365-pfd capacitor. Obviously, this unit is designed for use in the broadcast band, and will work with any broadcast receiver. Modulation is applied by the "brute force" method. Q1's base voltage passes through a carbon microphone which acts like a variable resistor, one whose resistance varies with the force of applied speech. The resultant fluctuating (or modulated) direct current is applied to the transistor base, causing the output oscillations to carry the voice intelligence, along with the broadcast carrier, to the antenna. According to FCC regulations, antenna length must not exceed 10 feet.

While the application of this circuit is limited by the fact that a carbon microphone must be used, the receiver circuit



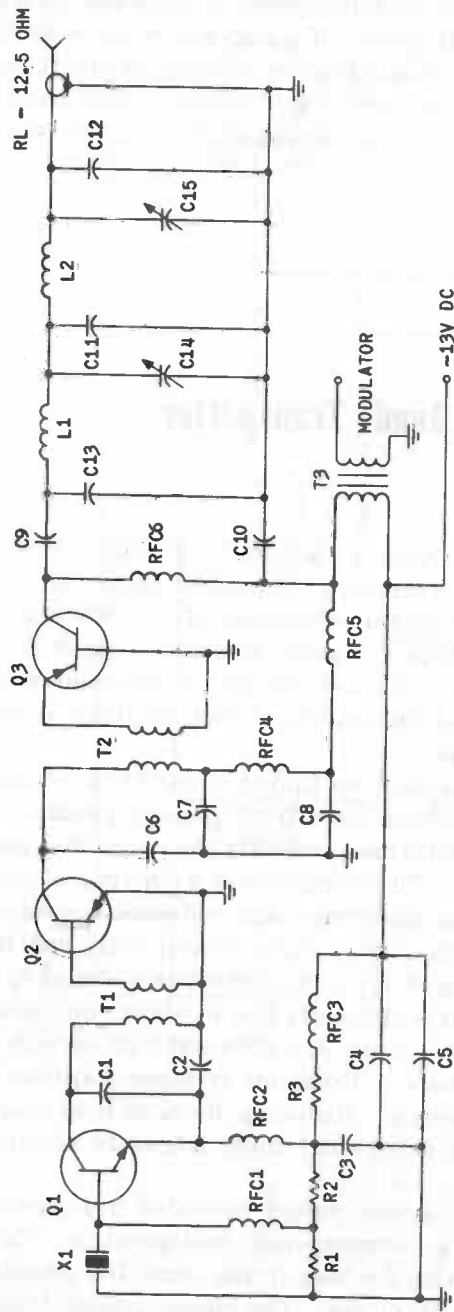
can easily be modified by substituting a relay in place of the loudspeaker. Then, when the microphone is activated by the user's voice, the relay will close. If a latching relay is used, the receiver can then be operated to any number of electrical devices, providing the user with voice control. The circuit would also make a fine one-way wireless intercom for baby-sitting purposes.

## Marine Band Transmitter

This transmitter will provide a 13-watt 2.185-MHz carrier with an overall current drain of 1.5 amperes from a 13-volt DC supply. It boasts an overall efficiency of 65% with envelope distortion of 5%. Required audio modulation input is 12 watts into a 6-ohm load. T1 and T2 are close-coupled on toroid forms and are used for matching the interstage 5-ohm outputs to the 48-ohm inputs.

The grounded-base Colpitts oscillator employs a series-mode crystal in the feedback path from base to ground. A close-coupled tuned transformer connects the oscillator output (30 mw) to the driver. The transformer primary, in conjunction with the leakage reactance and reflected reactance from the secondary, forms the 11  $\mu$ h oscillator coil, and the required collector loading of 770 ohms provides a loaded Q of 5 at 2.185 MHz. The Q is sufficiently low to allow continuous crystal operation between 2.0 and 2.4 MHz and high enough to preserve a good waveshape. Complete frequency spread to 2.85 MHz requires retuning. Reducing the Q to less than 5 distorts the oscillator waveshape and might introduce stability problems.

The common-emitter driver stage provides a somewhat higher gain than would a common-base configuration. Zero bias is obtained by returning the base to the same DC potential as the emitter with an RF choke. The close-coupled transformer used in the driver-collector circuit is wound on a



#### PARTS LIST

TRANSISTORS:  
 Q1—2N3298  
 Q2—MM1900  
 Q3—2N2832  
 CAPACITORS:  
 C1—470 pfd  
 C2—.02 mfd  
 C3, 5, 7, 8, 9, 10—.1 mfd  
 C4—.01 mfd  
 C6—4700 pfd  
 C11—5600 pfd  
 C12—3900 pfd  
 C13—1200 pfd  
 C14, 15—output tuning capacitors. Value determined on the inductance of L1 and L2.

#### RESISTORS:

R1—18K  
 R2—2K  
 R3—200 ohms

#### COILS:

L1, 2—output network coils. Inductance determined by value of C14, C15.  
 RFC1 to 6—50  $\mu$ h

#### TRANSFORMERS:

T1, 2—5 to 48-ohm coupling transformers  
 T3—12w modulation transformer (see text)

#### MISCELLANEOUS:

X1—2.185-MHz crystal

Courtesy: Motorola

## 40-Watt CW Transmitter

Designed for 40 watts CW, this transmitter circuit is suitable for many communications in the 50-MHz range. As is, it's ideal for amateur and other CW transmissions, or by adding a modulator it is easily adaptable for ham phone or other situations requiring voice communications. If your frequency is close to 50 MHz (within several MHz), the LC combinations shown will probably serve the purpose, or LC ratios may be changed accordingly, of course. While any standard modulation method will work with this transmitter, two immediately seem most appropriate: low-level modulation at Q3, or high-level modulation at Q2. If you want a continuously-variable frequency, substitute a VFO for the crystal.

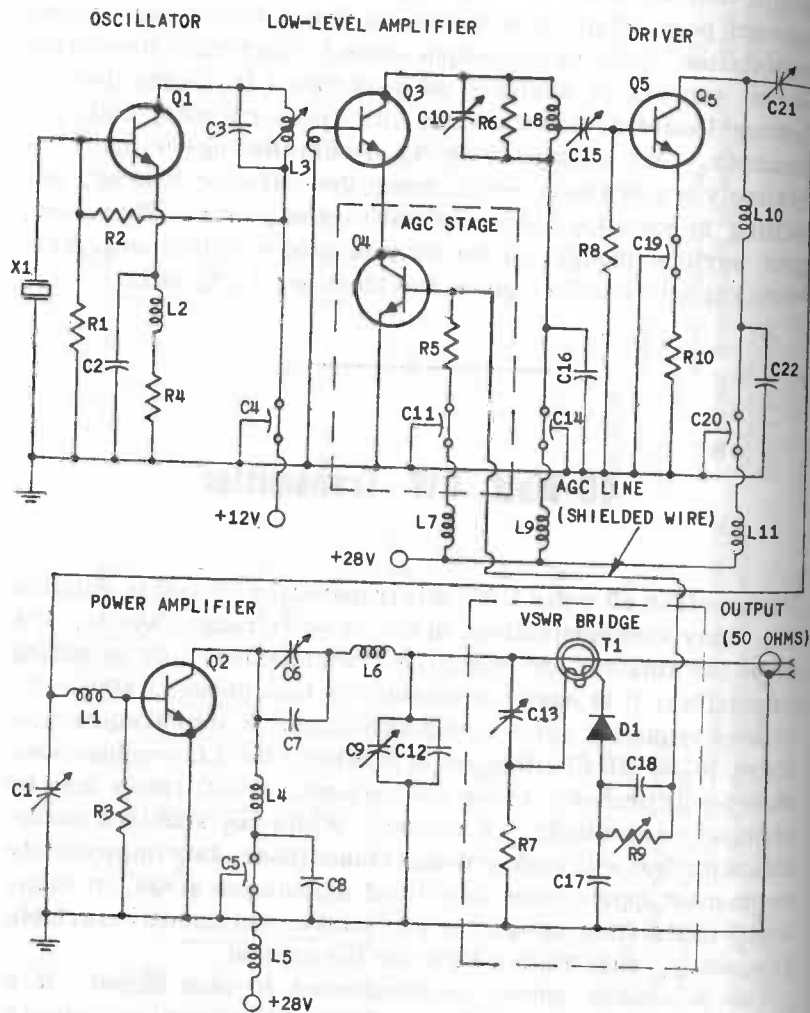
The schematic shows an unbalanced 50-ohm output. If a balanced output is required, a suitable coil-capacitor network may be connected from the output leg through T1 to ground,

toroid form, because excellent flux containment reduces coupling problems. In fact, the toroid can be laid flat on the chassis with little or no insertion loss. This transforms the input impedance of the output stage (5 ohms) to the required driver collector loading (48 ohms). Leakage reactance is tuned at the primary with a fixed capacitor.

The output stage is operated in common-base configuration. While this provides less power gain, the upward modulation characteristics are superior. Both driver and output are collector-modulated. Driver modulation provides the necessary upward peak to provide maximum drive during the upward modulation cycle of the output stage. The double pi-section output network is designed to work into a 12.5-ohm load, a bottom-loaded 9.5-foot antenna with a center loading coil, for example. Any change in the 12.5-ohm loading—either resistively or reactively—will change the collector loading, resulting in envelope distortion and loss of power. Therefore, give serious thought to the antenna used with this unit. Network capacitor values given are ideal for 2.185 MHz.

using a variable capacitor as a means of tuning. Another way, and perhaps easier, is to use an impedance-matching balun at the existing 50-ohm output.

Unique among the transmitter circuits in this book is the AGC stage (Q4). Transmitter power output may be varied (and held constant) by adjusting R9. The circuit's power requirements (12 and 28v) make the transmitter readily adaptable to base station or mobile operation.



Courtesy: RCA

## PARTS LIST

### TRANSISTORS:

- Q1, 3—2N3118
- Q2—40341
- Q4—2N3053
- Q5—2N3375

### DIODE:

- D1—1N3067

### CAPACITORS:

- C1—variable capacitor, 90 to 400 pfd, Arco #429 or equiv.
- C2—51 pfd, mica
- C3—30 pfd, ceramic
- C4, 5, 11, 14, 19, 20—feed-through capacitor, 1000 pfd
- C6—variable capacitor, 1.5 to 20 pfd, Arco #402 or equiv.
- C7—36 pfd mica
- C8, 16, 22—0.02 mfd ceramic
- C9, 10—variable capacitor, 8 to 60 pfd, Arco #404 or equiv.
- C12—91 pfd mica
- C13—variable capacitor, 0.9 to 7 pfd, Vitramon #400 or equiv.
- C15—variable capacitor, 14 to 150 pfd, Arco #426 or equiv.
- C17—1000 pfd ceramic
- C18—0.01 mfd ceramic
- C21—variable capacitor, 32 to 250 pfd, Vitromon #464 or equiv.

### RESISTORS:

- R1, 6—510 ohms
- R2—3.9K
- R3, 8—2.2 ohms wire-wound
- R4—51 ohms
- R5—24K
- R7—240 ohms
- R9—50K pot (AGC control)
- R10—5.6 ohms, 1w

### COILS:

- L1—1 turn of #16 wire; inner diameter, 5/16"; length, 1/8"
- L2—RF choke, 1  $\mu$ h
- L3—oscillator coil; primary, 7 turns; secondary, 1 3/4 turns; wound from #22 wire on CTC coil form having "white dot" core
- L4—5 turns of #16 wire; inner diameter, 5/16"; length, 1/2"
- L5, 7, 9, 10, 11—RF choke, 7  $\mu$ h
- L6—4 turns of B & W #3006 coil stock
- L8—6 turns of #16 wire; inner diameter, 3/8"; length, 3/4"

### TRANSFORMER:

- T1—current transformer (toroid), Arnold #A4-437-125-SF, or equiv.

### MISCELLANEOUS:

- X1—Crystal, required frequency

## 100-Watt Linear Amplifier

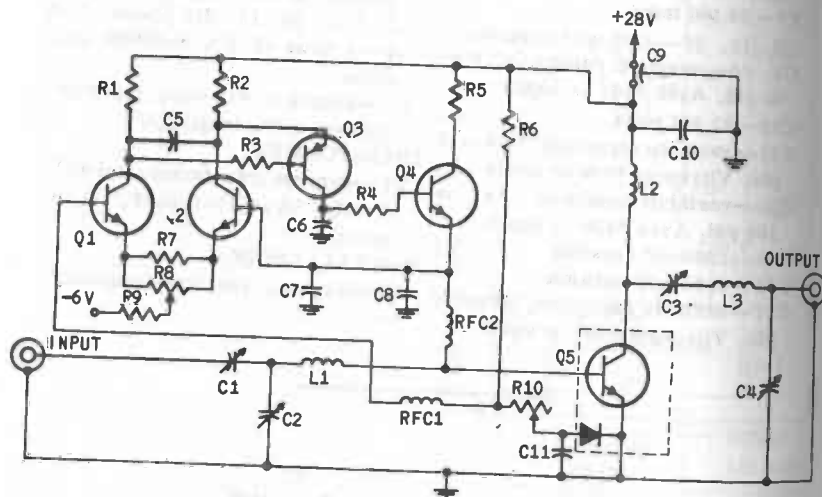
A Class A linear amplifier provides a faithful reproduction of the input signal, but not without some cost in efficiency. If it strikes you as strange that inefficiency is deliberately designed into an amplifier, bear in mind that it is often a strict requirement that the output envelope be an exact amplified duplicate of the input envelope. A typical case where this might be true is when a low-level transmitter is used to drive an amplifier of another transmitter with a modulated continuous wave (A-3). To increase the transmitter power, you would



also have to increase the modulation level as well. However, by using a Class A circuit such as this, the modulated continuous wave output from the low-level transmitter may be applied directly to the input of this unit, and result in a modulated output at an increase of 100 watts.

You will notice that no values are given for the input circuit components C1, C2, L1, and RFC. Similarly, no values are provided for the output circuit components C3, C4, L3, and the RF chokes. These must be determined at the operating frequency.

A suitable power source must also be provided for this amplifier, and due to the nature of the design, the power supply should be relatively free of ripple. The unit can be used as a mobile system in an automobile or in a boat, either on amateur or marine frequencies.



#### PARTS LIST

##### TRANSISTORS:

- Q1, 2—2N3053
- Q3—40319
- Q4—40251
- Q5—TA2758

##### CAPACITORS:

- C1, 2, 3, 4—see text
- C5, 6—1 mfd
- C7, 11—.0027 mfd
- C8—100 mfd
- C9—1000 pfd, feedthrough
- C10—.03 mfd

##### RESISTORS:

- R1, 2—2K
- R3, 4—500 ohms
- R5—50 ohms
- R6—12K
- R7—20 ohms
- R8, 10—100-ohm pot
- R9—510 ohms

##### COILS:

- L1, 2, 3—see text
- RFC1, 2—see text

Courtesy: RCA

## 500-MHz One-Watt Oscillator

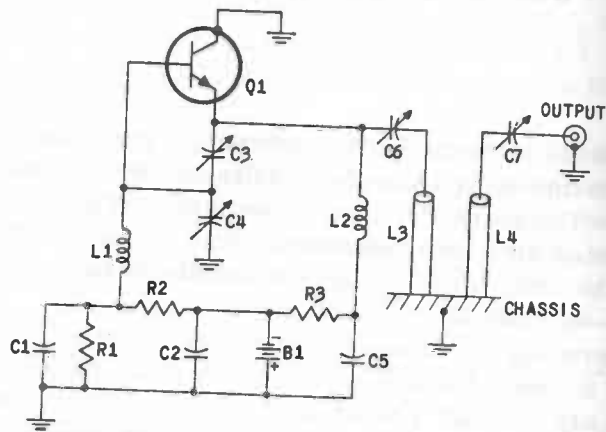
This circuit is particularly interesting, for the author can recall the time when a transistor salesman smiled indulgently and said "I'm sorry sir, transistors just don't operate at 500 megacycles yet, and they never will." Well, perhaps in a sense, he's right. After all, 500 megaHertz isn't 500 megacycles—semantically.

Compared to low-frequency circuits, there is an unusual section in this schematic. Take a look at L3 and L4. These "coils" are actually Lecher bars—parallel brass rods only 1 1/4 inches long! You will also notice (see parts list) that they are separated by 3/8" spacing. This spacing is highly critical, for the bars do indeed form the two output tank circuit inductances, the space between them serving as the dielectric for the output capacitance. At higher frequencies you often find Lecher bars in use, and their length is a function of the frequency at which they are operated.

When you design for high frequencies you must reckon with a phenomenon known as "skin effect," the tendency of a high-frequency electric current to travel along the surface of a conductor rather than through it. This characteristic was put to good use on high-power radar systems where the power was such that conductors became excessively hot. Thermally hot, not just electrically hot. To get around this, some unknown genius, realizing that the current traveled close to the surface of the conductors, used copper tubing as a conductor and pumped a liquid coolant through it. Electrical characteristics were unharmed, due to skin effect, and non-conducting fittings were used to maintain the coolant flow. As a result of this technique, early radar systems were often referred to as "plumber's nightmares."

Admittedly, the 500-MHz region is sparsely populated, and a circuit of this type is primarily of service to UHF experi-

menters. However, with some additional experimentation, there is no reason why this circuit can't be adapted to the 465-MHz citizens band for control and signaling applications. The amateur radio television frequency is in this range also, and this could serve as an excellent oscillator/driver for a 465-MHz TV transmitter.



Courtesy: RCA

#### PARTS LIST

##### TRANSISTOR:

Q1—2N3553

##### CAPACITORS:

C1—500 pfd ceramic disc

C2—0.01 mfd ceramic disc

C3, 6, 7—variable capacitor, 1. to 20 pfd, Arco 402 or equiv.

C4—variable capacitor, 0.9 to pfd, Vitromon #400 or equiv.

C5—50 pfd ceramic disc

##### RESISTORS:

R1—1.8K

R2—75 ohms

R3—2.7K

##### COILS:

L1, 2—RF chokes, 0.22  $\mu$ h, Nytronics #60Z189 or equiv.

L3, 4—parallel brass rods, 1 1/4" in length, 3/16" in diameter, separated by 3/8"

##### BATTERY:

B1—28v

## 300/600v Power Supply

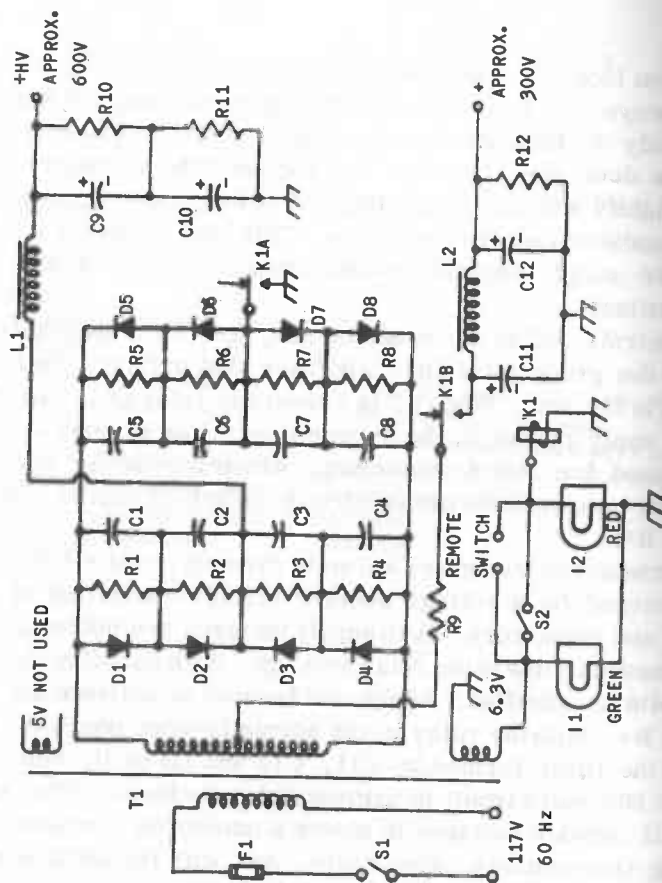
When you look at transmitter schematic diagrams, it seems they always tell you what power supply voltages are needed but rarely do they give you a typical supply. The supplies that one does see often use big vacuum tube rectifiers that glow brightly and are completely out of keeping with modern-day transistorized transmitters. This unit makes a rather complete supply capable of delivering 300/600v at 330 ma (intermittent).

S1 controls AC to the transformer, and when switch S1 is closed the green pilot light signifies that primary power is flowing in the unit. When S2 is closed the relay (K1) will pull in and apply power to the transmitter. The jumper across S2 is used for remote switching, which means that you can use your microphone press-to-talk switch to control transmitter B+.

The transformer supplies 300 volts directly, while 600 volts is developed by a voltage doubler circuit consisting of the diodes and capacitors. Both supply voltages are not available simultaneously due to the relay hook-up. With the relay closed, 300 volts is supplied, which can be used to activate the receiver B+. With the relay in the normally-open position, the B+ to the filter formed by C11, C12 and L2 is disconnected and the 600-volt circuit is ungrounded and closed. This supply will provide voltages to power a number of circuits, including transmitters, amplifiers, and with the addition of a couple of meters in appropriate circuits it can function as an all-around bench supply in the laboratory.

PARTS LIST

- DIODES:**  
D1 to D8—1N2864
- CAPACITORS:**  
C1, 2, 3, 4, 5, 6, 7, 8—0.001 mfd, ceramic disc, 1kv  
C9, 10, 11, 12—40 mfd electrolytic, 450v
- RESISTORS:**  
R1, 2, 3, 4, 5, 6, 7, 8—0.47 meg  
R9—47 ohms, 1w  
R10, 11—15K, 10w  
R12—47K, 2w
- COILS:**  
L1—2.8 henries, 300 ma; Stancor C-2334 or equiv.  
L2—4 henries, 300 ma; Stancor C-1410 or equiv.
- TRANSFORMER:**  
T1—power transformer Stancor P-8166 or equiv.
- MISCELLANEOUS:**  
F1—5 amp fuse  
I1—indicator lamp  
I2—indicator lamp  
K1—relay; Potter and Brumfield KAL1AY or equiv.



Courtesy: RCA

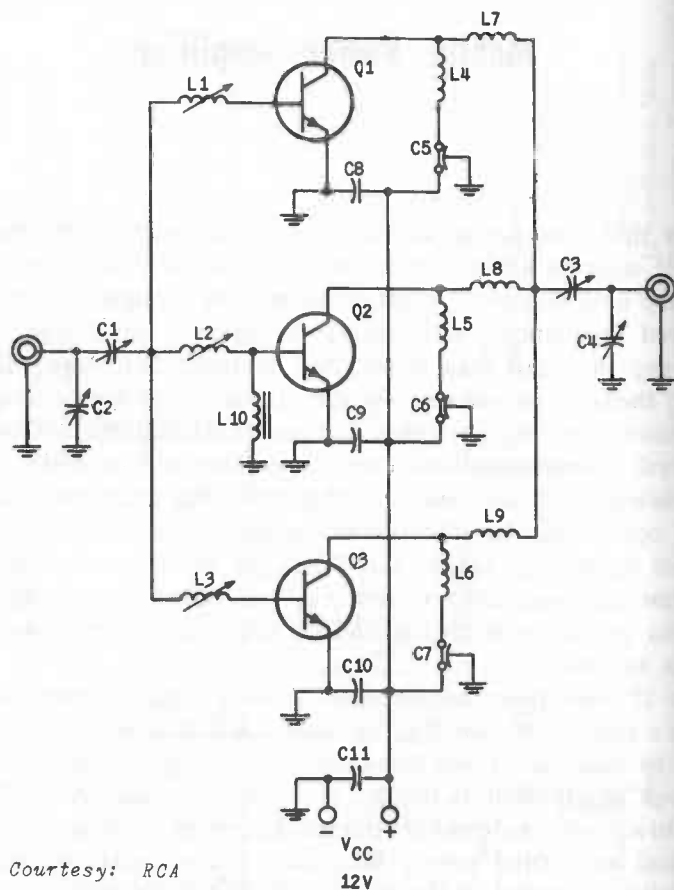
## Mobile Power Amplifier

While this circuit was intended for use in the 50-MHz range, it will operate satisfactorily at lower frequencies, provided that the coil/capacitor configurations are changed to tune the desired frequency. Obviously, in light of the design parameters, this unit was meant for amateur radio use. However, there is no reason why the circuit could not be adapted for other services, provided that power limitations set by the Federal Communications Commission are not exceeded. As an example, a unit such as this could be built for citizens band operation, but the power rating would well exceed the 5-watt maximum set by the FCC. It could be used on the marine and amateur frequencies, and (after proper investigation) possibly on police and/or other emergency service bands as well.

The 12-volt power requirement at once suggests applicability as a mobile station rig, but with a suitable supply it could also be used as a fixed-base amplifier. Again, be sure that if such application is made, the supply voltage AC ripple is held to a minimum to avoid transmitting hum. If the amplifier is used as a final power amplifier it can be driven with an unmodulated signal of low power. High-level modulation may be applied across the emitter of Q2.

The best way to tune the circuit is to start with a dummy load. It is important that the transistors do not absorb the load, but pass it quickly to the antenna. Toward this end, start by peaking all the coils and capacitors with a grid-dipper to get them close to the operating frequency. Have the driver properly tuned in the normal fashion as well. When you turn the unit on, quickly tune the capacitors for maximum lamp glow; then, (more carefully) do a fine-tuning job for maximum output. Take off the dummy load after shutting down the rig and

replace it with your antenna. Now turn the set on again, and retune C3 and C4 for maximum output as indicated by a field strength meter. Again, repeat all the adjustments with the antenna, just to make sure you're on the button.



Courtesy: RCA

#### PARTS LIST

##### TRANSISTORS:

Q1, 2, 3—40340

##### CAPACITORS:

C1, 3—65-340 pfd

C2, 4—100-550 pfd

C5, 6, 7—1000 pfd feedthrough

C8, 9, 10—1800 pfd ceramic

C11—.2 mfd ceramic

##### COILS:

L1, 2, 3—2 1/2 turns #16 wire,  
9/32" ID, 1/4" long

L4, 5, 6—3 1/2 turns #18 wire,  
1/4" ID, 3/16" long

L7, 8, 9—4 turns #14 wire, 3/8"  
ID, 1/2" long

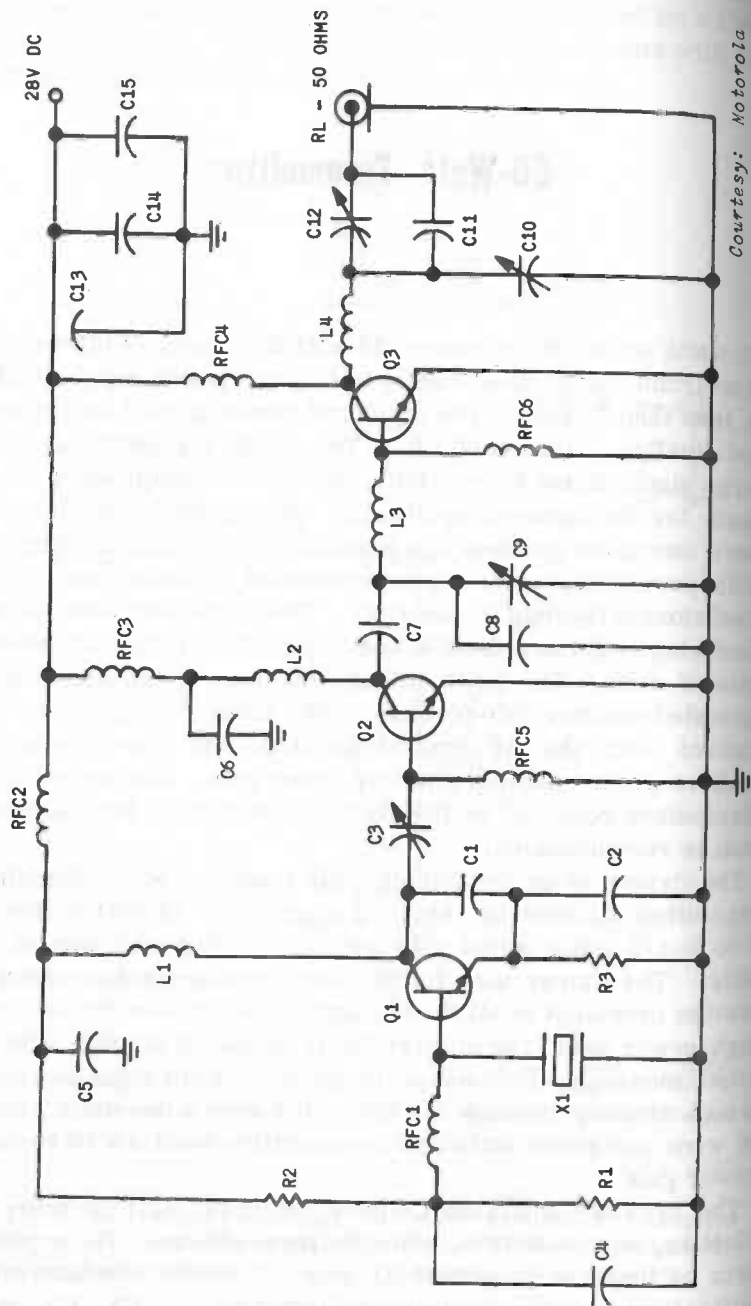
L10—ferrite choke, Z = 450 ohms  
(L1-3 use General Ceramics Q2  
material, 1/4"—28 x 3/8")

## 50-Watt Transmitter

50 watts at 50 MHz from a 28-volt DC supply is offered by this circuit. Overall efficiency is 62% and power supply drain is less than 3 amps. The combined power gain of the driver and final is a typical 27 db. The design approach employs large signal Class C transistor input/output admittances as a basis for the network synthesis. This method permits network design to proceed in a precise, mathematical manner, while providing a better representation of the actual operating conditions of the final transmitter. The transistor used in the final stage (Q3) is a 2N3950 operating with a minimum power gain of 8 db. The NPN silicon transistor is mounted in a grounded-emitter TO-60 case. The large package area in contact with the RF ground provides the low-impedance emitter-ground path so vital for power gain. Due to the high dissipation required in the final, a Wakefield FC-502 heat sink is recommended.

The driver stage transistor (Q2) requires power handling capacities dictated by the final stage. The 2N3961 delivers 6 to 6-1/2 watts output with typically 18 db power gain at 50 MHz. The driver also follows the common-emitter configuration prevalent in all three stages. To achieve the desired high power gain, the emitter DC is grounded through a low-impedance path. This means the ground circuit must be completed directly through the case, for even a one-inch length of wire can cause sufficient degenerative feedback to reduce power gain.

The crystal-controlled Colpitts oscillator (Q1) operates at 50 MHz, using a 2N4072, which delivers 100 mw. The crystal acts as the base-to-ground RF path. A series resonant circuit is formed at the oscillator collector by L1, C1, C2, and the reactive portion of the reflected load impedance of the



Courtesy: Motorola

collector. The 5 - 80 pfd capacitor controls the power delivered to the driver and the coil tunes the oscillator collector to resonance. The circuit may be adapted to CW keying instead of FM modulation; amplitude modulation would exceed the ratings on the final.

#### PARTS LIST

##### TRANSISTORS:

Q1—2N4072  
Q2—2N3961  
Q3—2N3950

##### CAPACITORS:

C1—12 pfd  
C2—150 pfd  
C3—5-80 pfd  
C4, 5—1000 pfd  
C6—.005 mfd  
C7—30 pfd  
C8—62 pfd  
C9—9-180 pfd  
C10—5-50 pfd  
C11—15 pfd  
C12—1.5-15 pfd

C13—1000 pfd feedthrough

C14—.02 mfd

C15—.1 mfd

##### RESISTORS:

R1—2K  
R2—4.7K  
R3—750 ohms

##### COILS:

L1—0.15-0.20  $\mu$ h  
L2—0.12  $\mu$ h  
L3—0.058  $\mu$ h  
L4—0.22  $\mu$ h  
RFC1, 2—5.6  $\mu$ h  
RFC3, 4—3.9  $\mu$ h  
RFC5, 6—Q < 1

##### MISCELLANEOUS:

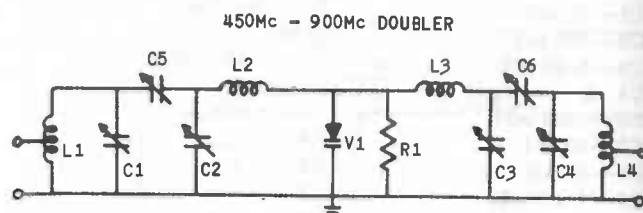
X1—50-MHz crystal

## Varactor Frequency Multiplier

In communications transmitters it is often desirable to use an oscillator crystal with a fundamental frequency far lower than the final output frequency. The usual method of increasing the frequency is to arrange a doubler (or tripler) stage, consisting of an amplifier using either a vacuum tube or a transistor whose input stage is tuned to the fundamental and whose output is an integral multiple of that fundamental frequency. Unfortunately, while this has been the standard practice for many years, the circuits have had several shortcomings: Vacuum-tube types would often drift off frequency as the tube and associated components heated, and even if cool-running

## CIRCUIT CHARACTERIZED VARACTOR DIODES

Type MA-	Package	Frequency Input-Output	Efficiency Min.	Input Power Watts	C <sub>o</sub> Pf	V <sub>o</sub> (at I <sub>o</sub> =10μa)	θ °C/W
4063	N	50 - 150 MC	60%	18	20-30	120	6
4064	N	150 - 450 MC	55%	11	20-30	90	6
4065	N	450 - 900 MC	50%	6	3-6	80	15
4083	S	1 - 4 Gc	30%	1.5	.8-1.6	48	75
4084	T	1 - 4 Gc	30%	1.5	.8-1.6	48	100
4085	T	4 - 12 Gc	25%	.75	.4-.8	24	150
4086	T	12 - 24 Gc	10%	.15	.2-.4	8	500



Courtesy: Microwave Associates

### PARTS LIST

#### VARACTOR:

V1—MA4065

#### CAPACITORS:

C1 to C4—VC22G, 1-18 pfd

C5, 6—PT901

#### RESISTOR:

R1—220K

#### COILS:

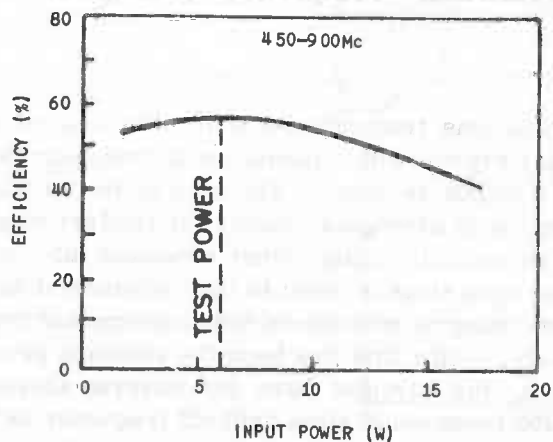
L1—2 turns, 1/2" dia. Tap 1/2 turn

L2—1 1/2 turns, 1/4" dia.

L3—1/4" copper band, .01" thick, 1/2" long

L4—1 turn, 1/4" dia. Tap 1/2 turn

(All coils air wound with #18 wire)



solid-state stages were employed the tuning circuits themselves often drifted or were subject to vibration and shock.

In the varactor circuit, as long as the associated voltages are held constant the varactor diode will hold constant, providing a high degree of reliability. This circuit is used primarily in radio transmitters, but it will function in a number of other RF circuits where frequency ranges fall between 50 MHz and 24 GHz.

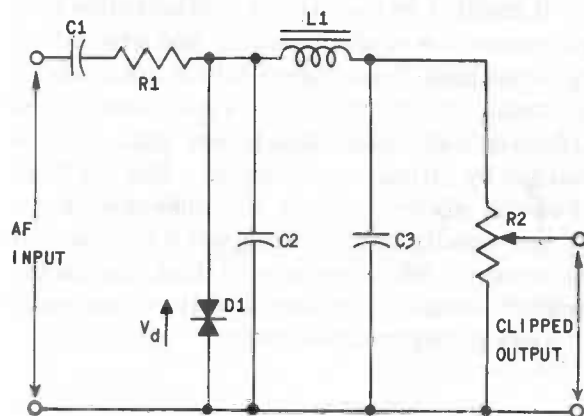
Admittedly, this is a fairly radical approach to frequency multiplication, for it implies in the circuit configuration that you are violating a prime law of electronics, and are indeed "getting something for nothing." However, this is not actually the case. If you consult the chart, there is a column called "% efficiency." Take a look under that to see what you are paying for what you get by efficiency decrease. But don't let this throw you. You can always amplify to compensate for a little inefficiency, and nobody has yet designed a circuit that was 100% efficient anyway! When you stop to think that in the past a frequency multiplier had to consist of at least one tube, we're still getting away pretty inexpensively.

## Zener Speech Clipper

Radio communications transmitters are limited in power input to the final amplifier stage. One way to obtain additional "talk power" without violating FCC regulations is to employ more useful speech components. In communications work we are more interested in usable range than in speech quality. You don't care if you sacrifice the mellifluous voice tones for a few extra miles of DX. One way to do this is by speech clipping, and the circuit shown can be used effectively in amateur radio, citizens band, business radio, or marine service.

Like so many devices, the zener diode helps solve a number of electronic problems. The zener current-voltage charac-

teristic has a sharp break at about 0.1 ma. Beyond this point, the voltage across the diode remains almost constant for currents up to the maximum value at the allowable power dissipation. The voltage characteristic is flat, like that of a gas-tube regulator. Power regulator diodes provide a wider choice of voltages and lower current ranges than do gas-tube regulators. In addition to these advantages, power regulators do not need firing voltage higher than the regulating voltage, as do the gas-tube types.



Courtesy: Texas Instruments

#### PARTS LIST

DIODE:  
D1—Zener

CAPACITORS:  
C1—.1 mfd  
C2—470 pfd  
C3—330 mfd

RESISTORS:  
R1—5K  
R2—500K pot

COIL:  
L1—20h, 15 ma

## Zener Protection for Power Amplifiers

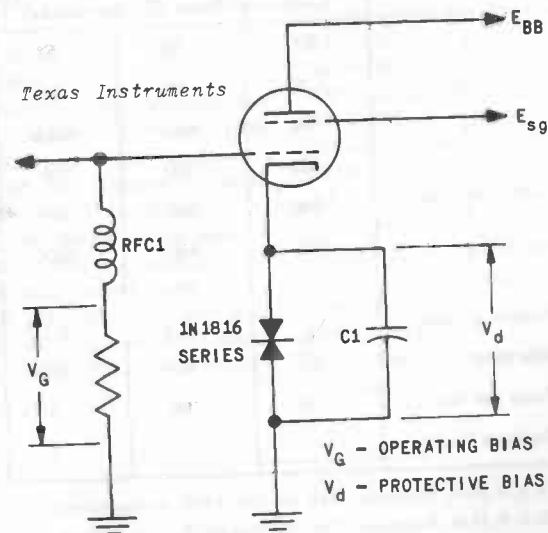
When excitation or drive is removed from a final or power amplifier tube, it can take off on its own and build up very quickly to levels beyond the tube's plate dissipation rating. In addition to allowing off-frequency emissions, you can easily destroy an expensive tube. The circuit shown here keeps this from happening by throwing protective bias on the tube when excitation ceases. It's somewhat like buying insurance—the zener adds nothing of its own to the range or quality of the

transmitter or amplifier, and you probably won't even miss it until you need it. Then you'll wish you had it!

It should be noted that the voltage between the plate and cathode is reduced by the amount of protective voltage  $V_d$ . The resulting operating bias may be obtained by subtracting the protective bias  $V_d$  from the grounded cathode operating bias. For proper heat sinking, the diode should be mounted on the transmitter chassis. Zener diode dissipation is the product of total cathode current and voltage  $V_d$ . Maximum diode dissipation at a specific case temperature can be obtained from the case

TUBE TYPE 807 $E_{BB} = 750$ v $E_{sg} = 300$ v $V_d = -32$ v	MAX DISSIPATION = 25 w $I_d = \frac{25 \text{ w}}{750} = 33$ ma FROM TUBE CHARACTERISTIC CURVES
TUBE TYPE 6146 $E_{BB} = 600$ v $E_{sg} = 200$ v $V_d = -43$ v	MAX DISSIPATION = 25 w $I_d = \frac{25 \text{ w}}{600} = 41.7$ ma FROM TUBE CHARACTERISTIC CURVES
TUBE TYPE 813 $E_{BB} = 1600$ v $E_{sg} = 300$ v $V_d = -22$ v	POWER DISSIPATION = 125 w $I_d = \frac{125 \text{ w}}{1600} = 78$ ma TOTAL OPERATING CURRENT $\cong 200$ ma

Courtesy: Texas Instruments



temperature vs power dissipation curve on the data sheet that comes with the diode. The chart shows parameters for three popular tube types, using the 1N1816 series zener. Zeners may be used with other output tubes, audio or RF. Since the zener is the only component added, a parts list is not included.

## FET VFO

A field effect transistor serves as the heart of this variable-frequency oscillator circuit. Since a VFO is most often used to replace a crystal oscillator circuit in a transmitter, it is important that you select a range compatible with the crystal frequencies being replaced; the crystal frequency and the

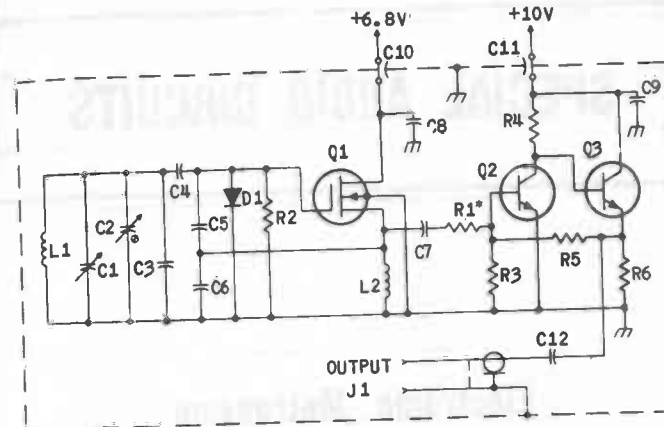
Tuned Circuit Data

Circuit Component	Frequency of Operation (MHz)		
	3.5 - 4.0	5.0 - 5.5	8.0 - 9.0
	Component Value (C = picofarads)		
C <sub>1</sub>	100	50	50
C <sub>2</sub>	25	25	25
C <sub>3</sub>	100	None	None
C <sub>4</sub>	390	390	270
C <sub>5</sub>	680	680	560
C <sub>6</sub>	680	680	560
L <sub>1</sub> :			
Number of turns	17 <sup>1</sup>	14-3/4 <sup>1</sup>	11-1/2 <sup>2</sup>
Wire size	20	20	18
Turns per inch	16	16	8
Diameter (inches)	1	1	1

<sup>1</sup> B & W 3015, Polycoils 1748, Air Dux 816T, or equivalent.

<sup>2</sup> B & W 3014, Polycoils 1746, Air Dux 808T, or equivalent.

terminal transmitter operating frequency are not always the same, remember! A glance at the chart will give you capacitor and coil values and specifications. If a frequency other than those listed in the chart is needed, you can use the basic circuit and design your own LC values.



\*ADJUST FOR 2V PEAK OUTPUT

Courtesy: RCA

### PARTS LIST

#### TRANSISTORS:

Q1—3N128 FET

Q2—40245

Q3—2N3241

#### DIODE:

D1—1N914

#### CAPACITORS:

C1—double-bearing variable capacitor, Millen 23100 or 23050 or equiv. (See Table for value.)

C2—25 pfd, air trimmer, Hammarlund APC-25 or equiv.

C3, 4, 5, 6—silver-mica capacitor, (See Table for value.)

C7—2200 pfd, silver mica

C8—0.05 pfd, 50v, ceramic disc

C9—0.1 pfd, 50v, ceramic disc

C10, 11—1500 pfd, feedthrough type

C12—0.025 mfd, 50v ceramic disc

#### RESISTORS:

R1—12 to 47K; select for 2-volt peak output level

R2—22K

R3—12K

R4—820 ohms

R5—47K

R6—240 ohms

#### COILS:

L1—inductance (See Table for characteristics)

L2—2.5 mh; miniature RF choke, iron core, Millen J300-2500 or equiv.

#### MISCELLANEOUS:

J1—coaxial connector, chassis mounting



## SPECIAL AUDIO CIRCUITS

### Electronic Metronome

Electronic metronomes may be used for just about anything that mechanical metronomes are used for, and more. The author, for example, has found this device useful in the photographic darkroom. With the metronome set for one-second intervals exactly, it eliminates the need for a clock that you couldn't see anyway! Just count off the clicks. R1 varies the click rate from about three to 250 per second. The only critical wiring is the connection from the transformer secondary. If everything checks out OK, and the unit still doesn't work, just try reversing the black and green wires from the transformer. It is important also to observe correct polarity of C1.

#### PARTS LIST

##### TRANSISTOR:

Q1—2N507

##### CAPACITOR:

C1—10 mfd electrolytic, 15v

##### RESISTORS:

R1—1 meg pot, linear

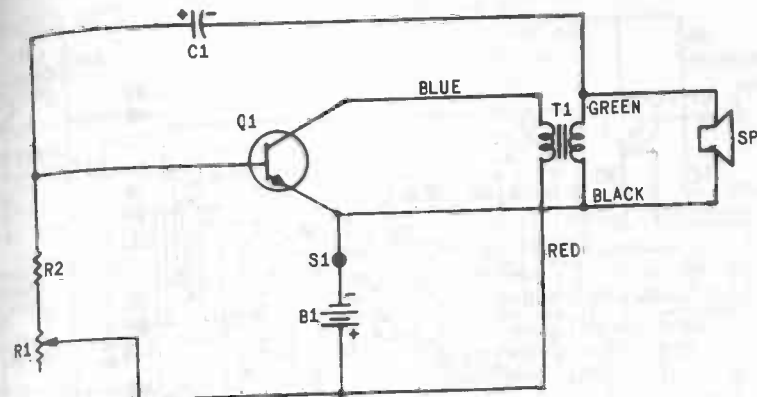
R2—10K

##### BATTERY:

B1—3v

##### TRANSFORMER:

T1—500-ohm primary, 3.2-ohm secondary

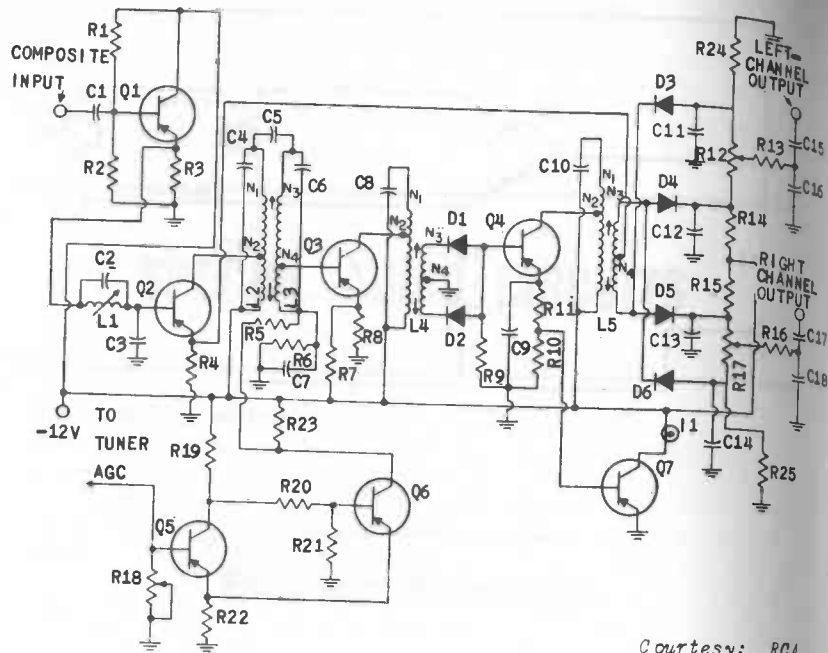


Courtesy: Radio Shack

### Multiplex Demodulator

At the time that stereo FM first made its appearance, the author was employed as electronics editor for Popular Mechanics Magazine in Chicago. The big news in hi-fi the previous year had been reverberation. The addition of reverberating echo chambers, coupled with L-pads to the "wing" speakers, seemed to open up the sound. But the word "reverberation" wasn't easily marketable. Along came "multiplex," or "multiplexors," and having been so recently burned by frightening words, the industry wisely settled on "stereo FM," which is a much easier mouthful.

The Zenith Corp. invited the press to witness the first stereo FM broadcast, and soon the exciting word was out. They were going to try to get on the air as soon after the legal time minimum specified for approval by the FCC had passed. We waited



Courtesy: RCA

breathlessly, excitedly, and at the stroke of the minute, the room filled with the glorious three-dimensional sound. The question was on everybody's lips, but to no avail. Time zone differences, daylight saving time, all worked against us, and New York City had beat us out. Shortly thereafter, many major FM equipment manufacturers were producing units similar to this, so that people who had bought mono FM tuners could adapt them for stereo. Unfortunately, some manufacturers, realizing that stereo was on the way, but not yet sure of sales potentials or markets, simply added an unconnected plug at the back chassis labeled "Multiplex Adapter." The implication was that all you would have to buy was an inexpensive unit to plug in, and there you were!

Today, most FM tuners are already equipped with stereo facilities that are built right in. However, if you have an older tuner around that's still operating mono, this circuit will convert it. Or if you're building a tuner from scratch, as you well might be if you read this book, be sure to include this adapter. If, the stereo light, will turn on when a stereo broadcast is being received.

## PARTS LIST

### TRANSISTORS:

Q1 to Q6—40359  
Q7—2N408

### DIODES:

D1 to D6—1N295

### CAPACITORS:

C1—0.33 mfd  
C2—560 pfd  
C3—300 pfd (adjust for optimum separation)  
C4—1000 pfd, part of L2  
C5—10 pfd  
C6—1000 pfd, part of L3  
C7, 9—0.47 mfd  
C8—1000 pfd, part of L4  
C10—390 pfd, part of L5  
C11, 12, 13, 14—7500 pfd,  $\pm 5\%$   
C15, 17—1.0 mfd  
C16, 18—0.02 mfd

### RESISTORS:

R1—91K  
R2—120K  
R3—6.8K  
R4—1K  
R5—18K  
R6, 13, 16, 21—3.3K  
R7, 9, 14, 15, 23, 24, 25—10K  
R8—510 ohms  
R10—220 ohms

R11—1.5K  
R12, 17—5K pot  
R18—10K pot  
R19—8.2K  
R20—15K  
R22—820 ohms

### COILS:

L1—10 mh,  $Q = 46$  at 67 kHz; Thompson - Ramo - Wooldridge #E0-14039-R1 or equiv.  
L2—69 mh,  $Q = 93$  at 19 kHz;  $N1/N2 = 5.66$ ; Thompson-Ramo-Wooldridge #E0-15484-R3 or equiv. (includes C4)  
L3—69 mh,  $Q = 93$  at 19 kHz;  $N1/N2 = 40.2$ ; Thompson-Ramo-Wooldridge #E0-15486-R3 or equiv. (includes C6)  
L4—69 mh,  $Q = 88$  at 19 kHz;  $N1/N2 = 5.24$ ,  $N1/N3 = .521$ ,  $N3/N4 = 2$ ; Thompson-Ramo-Wooldridge #E0-15360-R9 or equiv. (includes C8)  
L5—41 mh,  $Q = 108$  at 38 kHz;  $N1/N2 = 11.62$ ,  $N1/N3 = 19.8$ ,  $N3/N4 = 2$ ; Thompson-Ramo-Wooldridge #E0-15361-R7 or equiv. (includes C10)

### MISCELLANEOUS:

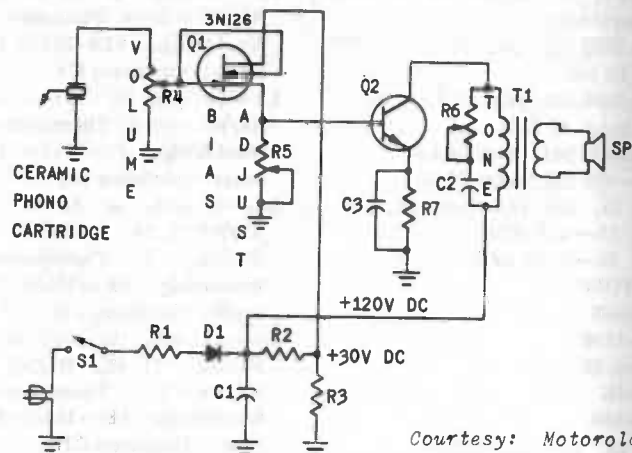
I1—stereo lamp, 14 ma, 10v

## Line-Operated Phono Amplifier

If there's one fly in the solid-state ointment, it's the fact that transistors operate at low input voltages, making batteries more convenient than an AC supply. This circuit combines FETs and high-voltage transistors to provide AC operation for a simple phono amplifier.

Very often, when you think in terms of phonographs, you ask yourself about design parameters and what can you get

for a dollar. The designer of this circuit (a very practical man) took a different stand. He wanted to know how LITTLE he'd have to spend to get good quality! The big factor, of course, is to eliminate the power transformer, which usually adds a few bucks to the cost. Unfortunately, available low-cost germanium power transistors usually have voltage breakdown points well under 100 volts, precluding their use in transformerless circuits.



Courtesy: Motorola

#### PARTS LIST

##### TRANSISTORS:

Q1—3N126 FET

Q2—MJE340

##### DIODE:

D1—1N4004

##### CAPACITORS:

C1—100 mfd electrolytic, 150v

C2—0.1 mfd, 400v

C3—100 mfd electrolytic, 3v

##### RESISTORS:

R1—330 ohm, 2w

R2—10K, 5w

R3—3K, 1w

R4—1K pot

R5—5K pot

R6—100K pot

R7—33 ohm

##### TRANSFORMER:

T1—Thordarson 24S53

The power supply shown here is a conventional half-wave rectifier operated directly from the 115-volt AC line. The rectifier is a Motorola 1N4004 surmetic silicon rectifier. The 330-ohm (R1) resistor in series with the rectifier has several purposes. It limits the DC rectifier voltage to about 120 volts so the audio output transistor has a breakdown voltage safety margin at "high line" conditions. The resistor also will burn open in the event excessive current is drawn through the circuit. Also, it limits surge through the diode when the unit is

first turned on, while capacitor C1 is charging. Q2's Vcc is taken directly from filter capacitor C1. A resistance divider supplies low voltage for the FET which has a 50-volt breakdown. Due to the low current drain of the 3N126 FET, no filter capacitor is needed. FET current will not exceed 7 ma.

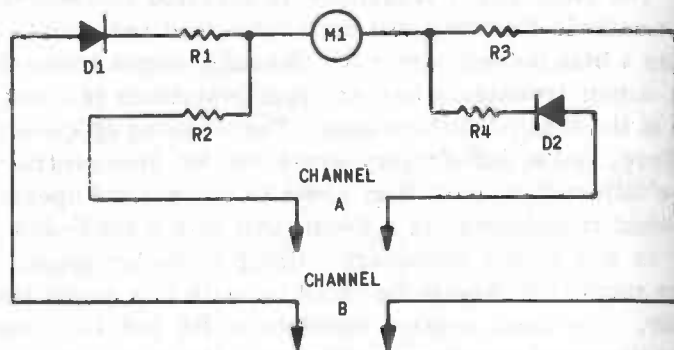
The amplifier portion is a two-stage direct-coupled type. A ceramic cartridge is connected across the 1 meg volume control. The field effect transistor is operated common-drain (like a cathode-follower) and the source load resistor is also used as a bias potentiometer for the audio output transistor.

The output transistor has an input resistance of about 150 ohms at the bias conditions used. The coupling efficiency is, therefore, quite satisfactory since the R5 bias control will not be adjusted to less than about 1K for normal operation. The output transformer is a 3-watt unit with a 2000-ohm primary to a 3.5-ohm secondary. Using an 8-ohm speaker T1 swings about 4000 ohms to the collector with this output transformer. The tone control consists of R6 and C2, placed across the output transformer primary. While the effects are pretty severe, this is a matter of engineering judgment and must be tailored to suit individual needs.

## Stereo Balancer

Very often, stereo equipment manufacturers prefer to have a pretty panel to having an accurate one. As a result, when balance controls are set "flat," they may not be. You can fiddle with the controls by ear, but you'll find a balance meter a lot more convenient. Channels A and B on the schematic connect to the stereo system's loudspeakers. The meter is a 0-1 ma type, with a zero center. When equal levels are received at both sides, the needle will be straight up. If you look elsewhere in this book, you'll find a square-wave generator circuit. Use that in conjunction with this circuit, and you've got an on-the-money team to make stereo adjustments!

You may find one small difficulty with this balancing circuit, and here's how to get around that: High-efficiency loudspeakers require less power from the amplifier to produce sound of a given level. As a result, there may not be sufficient drive from the amplifier to move the meter pointer sufficiently to obtain readings. If you raise the volume level enough to obtain a reading, the sound from the speakers can be



Courtesy: Radio Shack

#### PARTS LIST

##### DIODES:

D1, 2—1N34A

##### RESISTORS:

R1 to R4—330 ohm

##### MISCELLANEOUS:

M1—0-1 ma, zero center

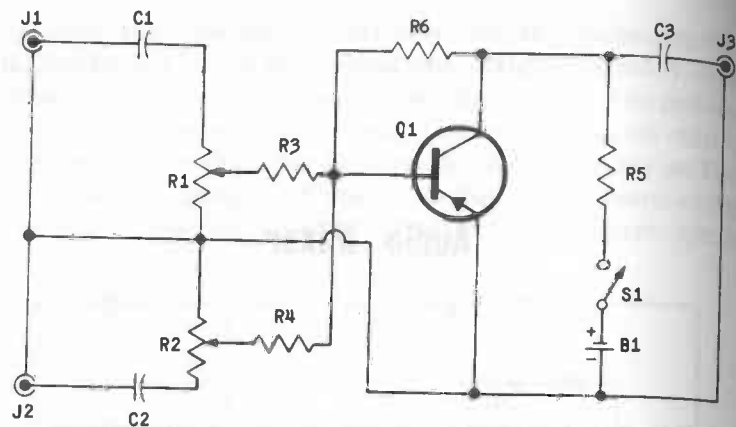
deafening. So, instead connect noninductive resistor dummy loads to the speaker terminals. Of course, with low-efficiency speakers, you'll have no problem. Another solution is to build a small stereo amplifier, and feed the stereo balancer from the speaker terminals through the small amplifier. Be sure to calibrate the pointer first by adjusting the auxiliary amplifier level controls.

## Audio Mixer

With this mixer circuit, you can connect a microphone and a guitar, or two microphones, or two guitars to a single amplifier or a tape recorder input. The jacks used should be selected to match the jacks and plugs on the equipment, and the entire unit should be mounted in a shielded, grounded metal box to reduce hum pickup. While you can mix signals without an amplifier, you will find that this sort of device enables you to properly balance the sound from each source. What's more, it permits proper coupling into the amplifier or tape deck.

Another excellent application for this circuit is sound motion picture production. With the advent of magnetic striped film and relatively inexpensive sound projectors, people are becoming more and more involved in this activity. In the beginning, most settle for a spoken narrative, but soon they want a bit more. Using a stereo tape recorder, first record the dialog on one track, then add the background music to the other track. Connect track 1 output to J1 and track 2 output to J2. Connect J3 to another tape recorder, and make a single tape consisting of a combination of tracks one and two.

Now record the combined music and sound-track tape onto track one of the stereo recorder. Rewind it to the start, and then, as it plays back track one, on which the music and dialog are recorded, record the sound effects on track two, using sound-on-sound techniques. Then connect the device as before, J1 to track 1, J2 to track 2, and J3 to the sound projector audio input. By running the sound-stripped film through the recording projector, you will blend all three sounds—dialog, background music, and sound effects on the film stripe. The result will be a professional sounding job.



Courtesy: Radio Shack

#### PARTS LIST

##### TRANSISTOR:

Q1—2N104

##### CAPACITORS:

C1, 2, 3—.5 mfd

##### RESISTORS:

R1, 2—500K pot

R3, 4—100K

R5—22K

R6—2.4 meg

##### BATTERY:

B1—1.5v

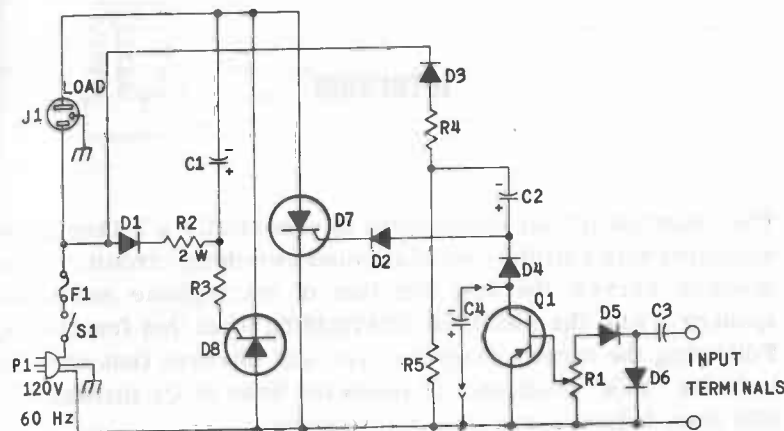
##### MISCELLANEOUS:

J1, 2, 3—jacks to match equipment

## SCR Voice Control

This audio-actuated switch can be used to control any device by the sound of your voice. You'll need about a volt to drive it, however, so be sure to use a small transistorized pre-amp between the mike and the input terminals. Vox boxes not only have practical uses, they can be lots of fun, too. The very things that tickle people about shooting guns, delight them about these units. Shooters like the idea of controlling power remotely! With this unit, you can (using a master/slave relay system) control the mightiest of motors, just by speaking one syllable!

More practically, amateur radio operators probably were the first to find a need for this circuit. In the early days of ham radio, switching from receive to transmit was a problem, one involving the fastest finger game in the world. You had to throw the antenna switch from the receiver to the transmitter, cut off the receiver B+, and turn on the transmitter B+ before you could talk. Then, happily, the coaxial relay



Courtesy: RCA

#### PARTS LIST

##### TRANSISTOR:

Q1—KD2101

##### DIODES:

D1 to D4—KD2103

D5, 6—1N34A

D7, 8—KD2100 SCR

##### CAPACITORS:

C1, 2—10 mfd electrolytic, 15v

C3—0.1 mfd, 200v, any type

C4—10 to 100 mfd electrolytic; to increase release time. 12v

##### RESISTORS:

R1—5K pot, 2w, linear

R2, 4—4.7K, 2w

R3—270 ohms

R5—470 ohms

##### MISCELLANEOUS:

J1, P1—3-wire AC plug and receptacle

F1—10 amp fuse

was invented, and by throwing only one switch (usually located on the mike as a push-to-talk switch) you were able to do all that switching with the relay. But this meant that you had to hang onto the mike, for to release it would put you back in the receive mode. Switches with locks helped, but you still had to flip the switch. Then along came the voice-actuated relay which solved all the problems. The first syllable you speak triggers the relay. By varying the value of C4, the circuit

release time is increased or decreased to prevent premature switching during short pauses or brief interruptions. The circuit may also be used to turn a tape recorder on and off or for any of a dozen other applications.

## Intercom

The intercom circuit shown here is essentially a 3-transistor amplifier with a slightly sophisticated switching circuit. Each speaker serves the dual function of microphone and loudspeaker, with the switches determining what that function is. Following the circuit diagram, you will observe that when S1 is in the "talk" position, T1 feeds the base of Q1 through C1. SP1 does indeed serve as a microphone.

### PARTS LIST

#### TRANSISTORS:

Q1, 2—2N107

Q3—2N270

#### CAPACITORS:

C1, 2—10 mfd electrolytic

C3—30 mfd electrolytic

#### RESISTORS:

R1, 3—470K

R2, 4—4.7K

R5, 6, 7—150 ohms

#### BATTERIES:

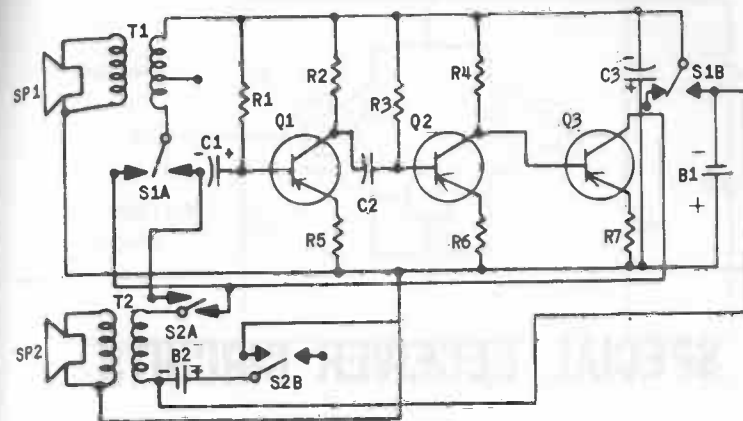
B1, 2—9v

#### TRANSFORMERS:

T1, 2—AF output, 500-ohm CT primary, 3.2-ohm secondary

At the same time, S1B is connected so that the output signal from Q3's emitter circuit is connected to transformer T2 feeding the signal to SP2 which then functions as a loudspeaker. With the circuit operating in this fashion, whatever is spoken into SP1 will be heard at SP2. By reversing switch S1, you reverse the process. S2 also provides a calling signal by feeding the amplifier output signal back to the input, causing it to oscillate and "howl."

The remote unit consists only of SP2, S2, and B2. Additional remote units may be added, connecting them the same as the first one, using 4-conductor cable.



Courtesy: Radio Shack

## SPECIAL RECEIVER CIRCUITS

### S-Meter

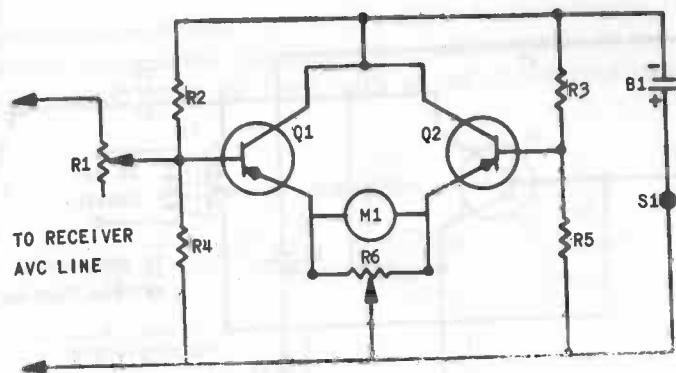
An S-meter indicates relative signal level and operates in the receiver AVC circuit. This circuit will work with communications receivers, ham receivers, marine-band receivers, or CB units. By balancing potentiometer R6 between Q1 and Q2, you effectively null the reading on the meter, or establish

#### PARTS LIST

TRANSISTORS:  
Q1, 2—2N109  
RESISTORS:  
R1—10K pot  
R2, 3—270K

R4, 5—10K  
R6—5K pot  
BATTERY:  
B1—9v  
MISCELLANEOUS:  
M1—0-1 milliammeter

the relative reading or zero-point. By installing a simple 1N34 diode in each input leg and recalibrating the scale, there is no reason why the unit could not be used as a VU meter as well.

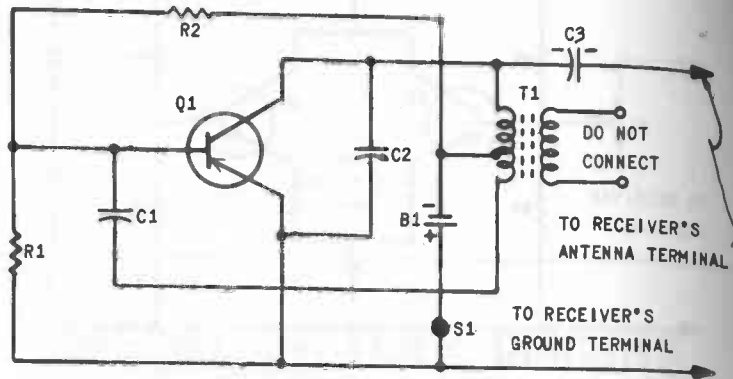


Courtesy: Radio Shack

### Beat Frequency Oscillator

If you ever owned a short-wave receiver, you may have heard the hissing sound resulting from ham CW transmissions. The long and short dashes and dots come across as hissing sounds because the carrier used at the transmitter is just that—a carrier being interrupted by the telegraph key. This mode of operation is called A-1, or interrupted carrier wave (ICW). To hear this as a continuous tone, a local signal must be added. This is the function of the BFO. Also single-side-band operation will sound garbled until the BFO is turned on to restore tone to the signal.

In the circuit shown here, C2 varies tone pitch. The circuit is connected to the receiver antenna terminals and injects an RF signal which beats with the incoming signal in the IF stages, producing an audible tone only when the incoming carrier is present.



Courtesy: Radio Shack

#### PARTS LIST

##### TRANSISTOR:

Q1—2N544

##### CAPACITORS:

C1—.01 mfd

C2—15 pfd trimmer

C3—.001 mfd

##### RESISTORS:

R1—4.7K

R2—10K

##### BATTERY:

B1—1.5v

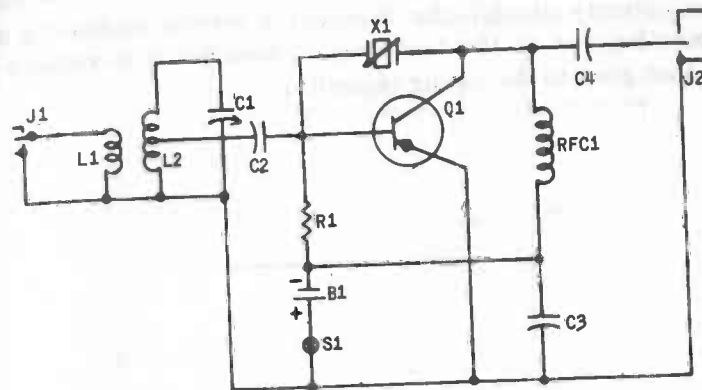
##### TRANSFORMER:

T1—IF transformer

## Short Wave Converter

They used to say "tune in the world," and with this unit attached to an automobile radio (depending on the frequencies used) it is possible to pick up police calls, hams, or even foreign broadcasts when atmospheric conditions are right. The auto antenna is connected to J1 and J2 to the radio antenna terminal. By changing crystals the desired frequencies are selected, so check on what particular frequencies you'd like to hear before you go out and buy crystals. The radio is tuned the same as before with the converter in place. The crystal frequency chart list several possible ranges.

Performance is improved with a short-wave antenna. Conventional automobile antenna stubs just won't work too well. If the circuit is to be used with an AC broadcast band re-



Courtesy: Radio Shack

#### CRYSTAL FREQUENCY

#### CAR RADIO TUNING RANGE

4450 KHz

5000 - 6050 KHz

5500

6050 - 7100

6450

7100 - 8050

7500

8050 - 9100

8550

9100 - 10150

#### PARTS LIST

##### TRANSISTOR:

Q1—2N247

##### CAPACITORS:

C1—100 pfd trimmer

C2—100 pfd ceramic

C3, 4—.001 mfd ceramic

##### RESISTOR:

R1—390K

##### COILS:

L1—9 turns hookup wire wound

around L2

L2—22 turns B & W miniductor #3016

RFC1—2.5 mH choke

##### BATTERY:

B1—4 1/2v D cells

##### MISCELLANEOUS:

X1—see chart

J1—auto radio antenna jack

J2—female coax connector SO239

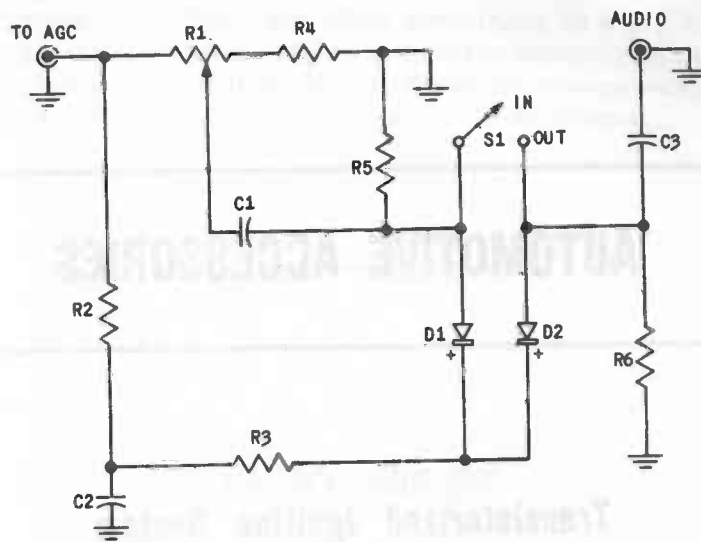


ceiver, watch your step in connecting it—a mistake in grounding can be a bit dangerous. Again, pay particular attention to antenna length when you use this with a transistor receiver. And to avoid having broadcast signals come in at the same time, simply disable the receiver's ferrite antenna by disconnecting one of the leads—your best bet is to remove the one that goes to the tuning capacitor.

## Noise Limiter

In communications work, noise is the result of random spikes on an amplitude modulated signal. It is the presence of these noise spikes that create squitter, static, or interference in an AM receiver. There are many sources of such noise, including noisy spark plugs in an automobile, a loose light bulb in a socket, or even a sewing machine motor with worn brushes. This noise limiter circuit is designed for installation between the AGC and receiver audio amplifier.

When noise problems are present, it is always best to try and find the source. Only when it is impossible to locate the source, or when the correction process is extremely involved or impossible, is a circuit like this necessary. However, noise may be coming from several sources simultaneously, in which case it's far easier to install this dual-diode noise limiter in the receiver circuit and eliminate the problem that way. This circuit is adaptable to a number of applications, including all amplitude modulation broadcast or short-wave receivers, high-fidelity tuners, etc. As the circuit requires no power, it is especially suitable for inclusion in transistorized receivers.



Courtesy: Radio Shack

### PARTS LIST

#### DIODES:

D1, 2—1N625

#### CAPACITORS:

C1—.02 mfd

C2, 3—.01 mfd

#### RESISTORS:

R1—500K pot

R2, 3—500K

R4—270K

R5, 6—1 meg

## AUTOMOTIVE ACCESSORIES

### Transistorized Ignition System

A standard automotive ignition system uses a circuit breaker (distributor) and a coil to generate a high-voltage spark. By inserting a transistor amplifier between the distributor and coil, you can generate a higher frequency spark, and therefore a more positive-acting one. Plugs fire better and more surely, and the higher frequency enables all combustibles in the vapor mixture to burn. This results in more efficient

#### PARTS LIST

##### TRANSISTORS:

Q1—2N3054

Q2—2N3055

##### DIODE:

D1—90v, 50w

##### RESISTORS:

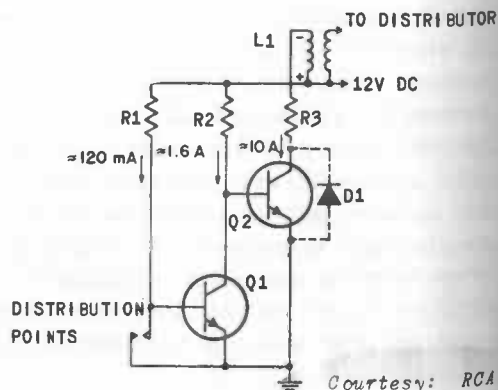
R1—100 ohms, 5w

R2—7.5 ohms, 25w

R3—1 ohm, 100w

##### COIL:

L1—ignition coil



Courtesy: RCA

operation. But there are other advantages as well. Spark plugs last longer because there is a lesser tendency of pitting and residue accumulation; in fact, the entire system—capacitor, distributor points, etc.—seems to last longer.

### Battery Charger

Basically, a battery charger consists of a system designed to provide a constant voltage source at a given current level. This is done by means of a step-down transformer, a rectifying system, a voltage regulator of some sort, a circuit-protecting device, and a means of either cutting off the supply when full charge is reached or of reducing the applied current level to a trickle charge. These two circuits possess all of these requirements, including an SCR and zener diode for regulation. In each case, an indicator lamp is used to indicate when the battery has reached full charge.

#### PARTS LIST

##### TRANSISTORS:

Q1, 2—KD2101

##### DIODES:

D1 to D4—KD2103

D5—KD2100 Zener

D6—KD2104

##### CAPACITOR:

C1—50 mfd electrolytic, 15v

##### RESISTORS:

R1—10K pot, 2w linear

R2—5 ohms, 20w (12v) or 2 ohms, 25w (6v)

R3—150 ohms

R4—470 ohms

R5—1.8K

R6—33 ohms

##### TRANSFORMER:

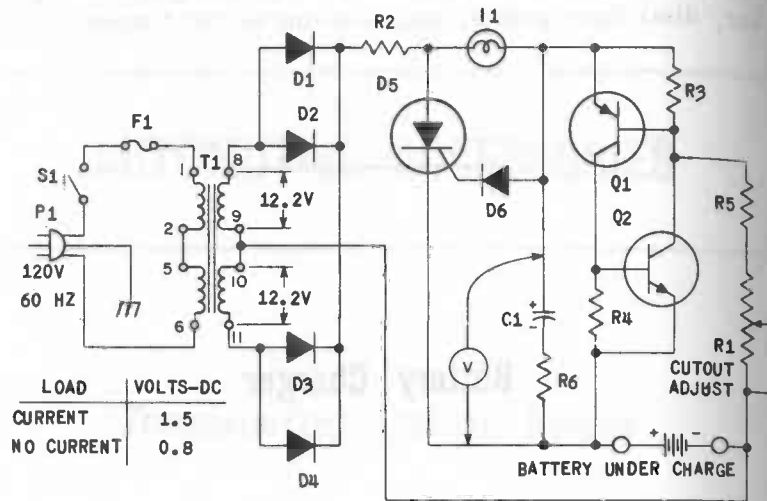
T1—120v to 24v (12v) or 120v to 14v (6v)

##### MISCELLANEOUS:

F1—1 amp fuse

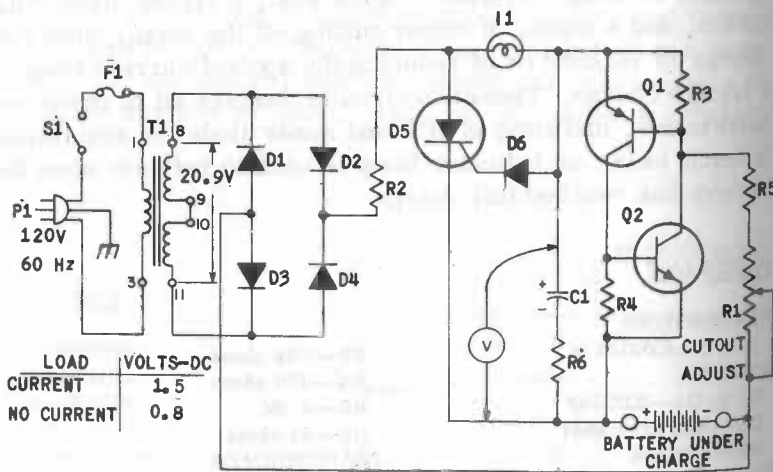
I1—G.E. 1448 (12v) or #47 (6v)

P1—3-wire AC plug



Courtesy: RCA

6-Volt Charger



Courtesy: RCA

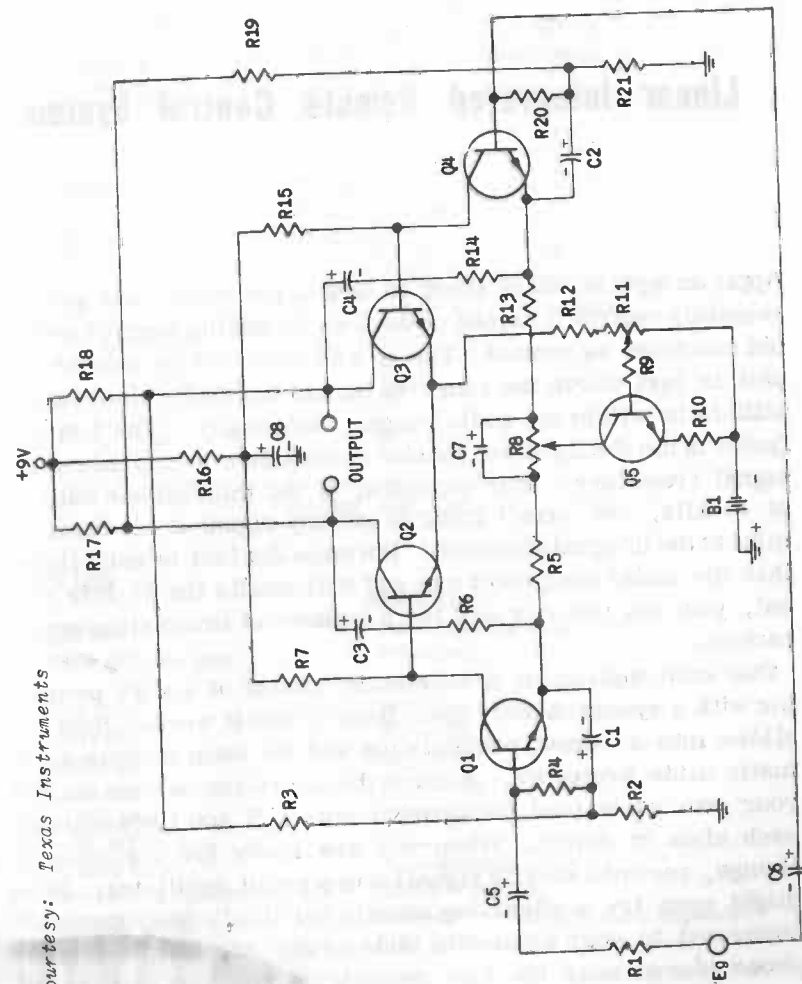
12-Volt Charger

Well-insulated heavy-gauge (at least #4 or 6) stranded cable should be used to connect the charger to the battery. Stranded wire is more flexible, particularly at the cable sizes in question. If you are building a charger, what are commonly called "jumper cables" (available at any auto supply store) serve the purpose nicely if you remove the insulated clips from one end of each cable and connect the cables to the charger.

# DIFFERENTIAL, INTEGRATED, AND COUNTER CIRCUITS

## Low-Noise Differential Amplifier

This high-impedance circuit consists of four transistors forming two direct-coupled differential stages. A fifth transistor (Q5) provides a constant total emitter current for the first stage of each pair (Q1 and Q4). Output-collector-to-opposing-input-base feedback stabilizes the transistor DC operating points. To keep AC signal components from lowering input impedance, shunt capacitors are used in the first stage emitter circuits. Overall AC voltage amplification is then controlled by output-collector-to-input-emitter feedback, which also raises the input impedance. To establish DC operating conditions, first adjust the 10K pot (R8) for a combined first stage collector current of  $30 \mu\text{a}$ , then adjust the other 10K pot



Courtesy: Texas Instruments

### PARTS LIST

#### TRANSISTORS:

Q1, 2, 3, 5—2N780  
Q4—TI490

#### CAPACITORS:

C1 to C4, 8—33 mfd electrolytic,  
15v

C5, 6—2.2 mfd electrolytic, 15v  
C7—4.7 mfd electrolytic, 15v

#### RESISTORS:

R1—5K

R2, 16, 21—56.2K

R3, 19—182K

R4, 6, 7, 14, 15, 20—51.1K

R5, 13—511 ohms

R8, 11—10K pot

R9, 10—3.01K

R12—14.7K

R17, 18—20K

BATTERY:

B1—1.5v

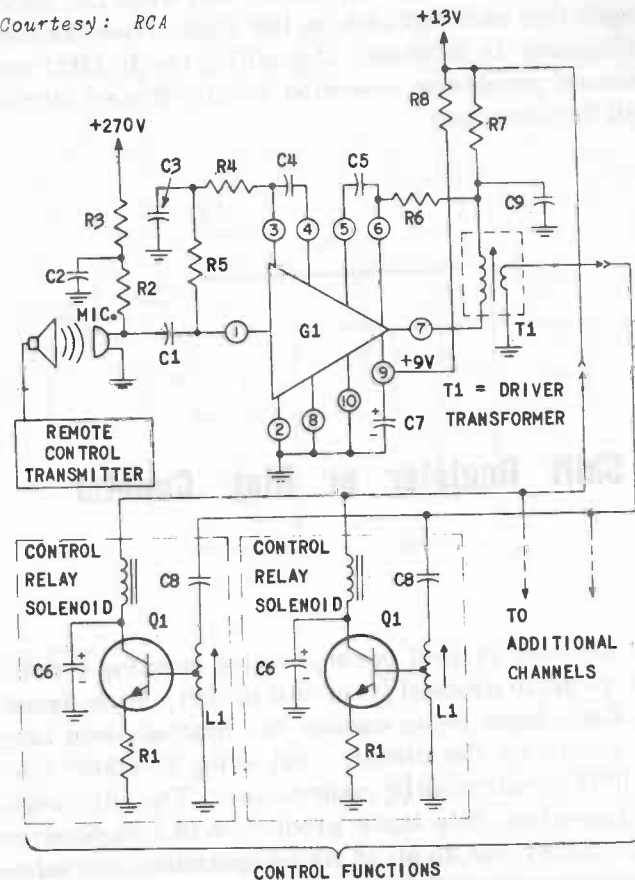
(R11) for zero differential output voltage. Because some interaction can occur, recheck the first pot. Used extensively in computer applications, this circuit (and variations of it) senses the relationship between two voltage (or current) conditions and produces a differential voltage reflecting balance or unbalance with the power supply or standard (B1).

## Linear Integrated Remote Control System

Apply an input signal of about 40 kHz to the mike, and you can remotely control a series of devices by adding control solenoid functions as needed. The 40 kHz required to operate this unit is just above the range of human hearing. However, it still falls within the audio range, technically. The limiting factor is the ability of your audio components to reproduce the signal frequency. For example, if the microphone cuts off at 12 kHz, you aren't going to get any signal at all from the mike to the integrated circuit! But once the fact is established that the audio equipment can and will handle the 40-kHz signal, you can use this unit for a number of interesting applications.

One such application is automatic control of a slide projector with a synchronized tape. Here's how it works: Sort the slides into a "show" presentation and put them in your automatic slide projector. Record the narration on tape so that your own voice (and background music if you like) explains each slide in detail. When you are ready for the slide to change, record a 40-kHz signal from a small oscillator. (You might even try a silent dog whistle for this!) With this unit connected to your automatic slide projector, and its microphone placed near the tape recorder's speaker, you're all

Courtesy: RCA



### PARTS LIST

#### TRANSISTOR:

Q1—use suitable type

#### IC:

G1—CA3035

#### CAPACITORS:

C1—4700 pfd

C2—.01 mfd

C3—.022 mfd

C4—.03 mfd

C5—.0022 mfd

C6, 7—10 mfd electrolytic etc

C8—depends on Q1

C9—.05 mfd

#### RESISTORS:

R1—depends on Q1

R2—100K

R3—1 meg

R4—150 ohms

R5—33K

R6—10K

R7—4.7K

R8—1K

#### COIL:

L1—depends on Q1

#### TRANSFORMER:

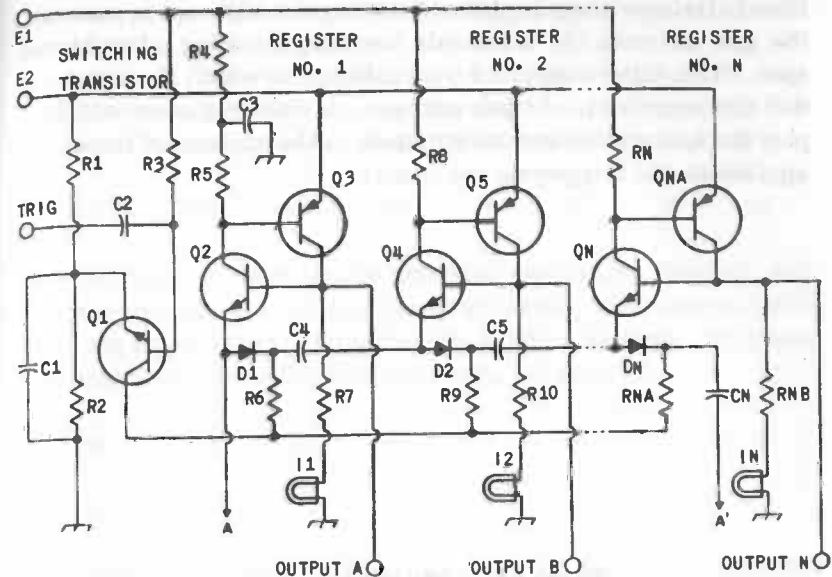
T1—driver transformer, depends on Q1

set. The tape recorder will start, and when the slide is to be changed this unit will pick up the signal from the tape. If your equipment is incapable of handling the 40 kHz, you can use a manual pushbutton-operated 40-kHz transmitter to accomplish the same end.

## Shift Register or Ring Counter

The shift register is used in consecutive counting circuits to enable the count to proceed from unit to unit, from decade to decade. Each input pulse causes the next adjacent lamp to fire. By extending the circuit, and using a "nixie" tube, a complete 0-10 counter can be constructed. The shift register plays an important role in the production of computer read-outs. A computer can do all of its computation, but unless it is able to communicate the results to man, the computations are valueless. The shift register is, in a sense, a transducer used to convert electronic information into a form for human utilization.

In the schematic you will observe that the second stage register is identical with the "n" stage register. It is coupled as shown by dotted lines. When the first switching transistor stage is triggered with the first pulse, lamp I1 will light. When a second pulse enters the base of the first transistor, I1 will extinguish, and the second lamp, I2, will light. Each succeeding pulse will cause the following lamp to light until all the lamps have gone on and then off. Then, the sequence is repeated. The shift register may use as many stages as desired and may be made regenerative by connecting points A and A1. In addition, the basic circuit can be adapted for



Courtesy: RCA

### PARTS LIST

#### TRANSISTORS:

Q1, 2, 4, N—2N1302  
Q3, 5, NA—2N404

#### DIODES:

D1, 2, N—1N34

#### CAPACITORS:

C1—100 mfd electrolytic, 6v  
C2, 4, 5, N—0.05 mfd (or 0.1 mfd), 50v ceramic  
C3—1 mfd, (or 25 mfd), 25v electrolytic

#### RESISTORS:

R1—1K (or 680 ohms, 1w)  
R2—27 ohms (or 12 ohms, 1w)  
R3—1K  
R4—1K (or 330 ohms)  
R5, 8, N—2.2K (or 680 ohms)  
R6, 9, NA—560 ohms (or 180 ohms, 1w)  
R7, 10, NB—150 ohms, 1w (or 82 ohms, 2w)  
MISCELLANEOUS:  
I1, 2, N—#49 or 1488

operation at many different output-current levels. This circuit as shown is designed for an output-current level of 40 ma ( $E1 = 12v$ ;  $E2 = 9v$ ). Transistor types and component values shown in parentheses indicate the changes necessary for operation at an output-current level of 3 amps ( $E1 = 27v$ ;  $E2 = 24v$ ).

The "nixie" tube mentioned is a tube similar in appearance to an ordinary octal base tube, except that it has 11 base pins. These pins lead to terminals placed around the tube, so that in looking down on the top of the tube you see the terminals as a ring. The tube is evacuated and back-filled with neon gas.

When a firing voltage is placed between two adjacent terminals, the gas between the terminals ionizes, forming a bright red spot. This tube is supplied with a bezel on which the numbers 0-9 are engraved. As you can see, a shift register will display the spot under the number equal to the amount of impulses applied to the triggering terminal.

## Bistable Multivibrator

This 1-MHz flip-flop is the heart of computer circuitry because it provides output either in an on or off mode, easily adjustable to binary readouts. When "1" is present as shown at the schematic, "0" appears where indicated. However, in the flopped mode, these reverse. Such units make excellent electronic switches, and they have been used as a means of observing two traces simultaneously on oscilloscopes, too.

We are accustomed to dealing with numbers in the decimal or "ten" system, and the depth of our involvement with "tens" doesn't really begin to show up until you expose yourself to another system. A typical example is the American who travels to Great Britain and gets snagged on shillings, pence, and pounds. In electronic counting, we use a base two system called "binary" arithmetic. The counting system is predicated on the fact that electronics can easily reproduce steady-state systems. A switch can either be on or off. A lamp can be either on or off. There are two steady-state conditions that are diametrically opposed. Consider then, the theory

that the on state is signified by the number one and the off state by the cipher zero.

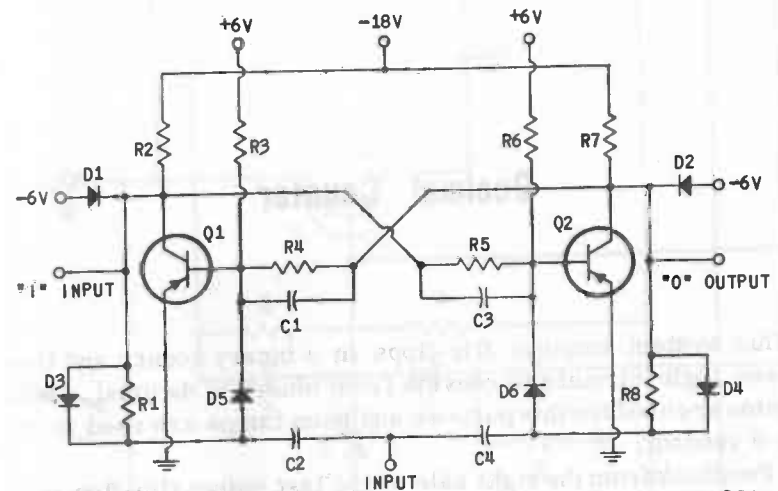
Starting at the right, place a zero, then moving left, the number one, followed by the number two, followed by the number four, and so on, doubling the number each time.

64    32    16    8    4    2    1    0

As you can see, this can be extended endlessly. Now we will use the number 1 to indicate an on situation, the cipher 0 will indicate an off mode. To write the number 82 then, we place our numbers under the key numbers, as follows:

64    32    16    8    4    2    1    0  
1    0    1    0    0    1    0    0

The binary number which represents 82 would be 10100100.



Courtesy: RCA

### PARTS LIST

#### TRANSISTORS:

Q1, 2—2N404

#### DIODES:

D1 to D6—1N126

#### CAPACITORS:

C1, 3—180 pfd mica, 24v

C2, 4—430 pfd mica, 24v

#### RESISTORS:

R1, 8—5.1K

R2, 7—1.2K

R3, 6—11K

R4, 5—2.7K

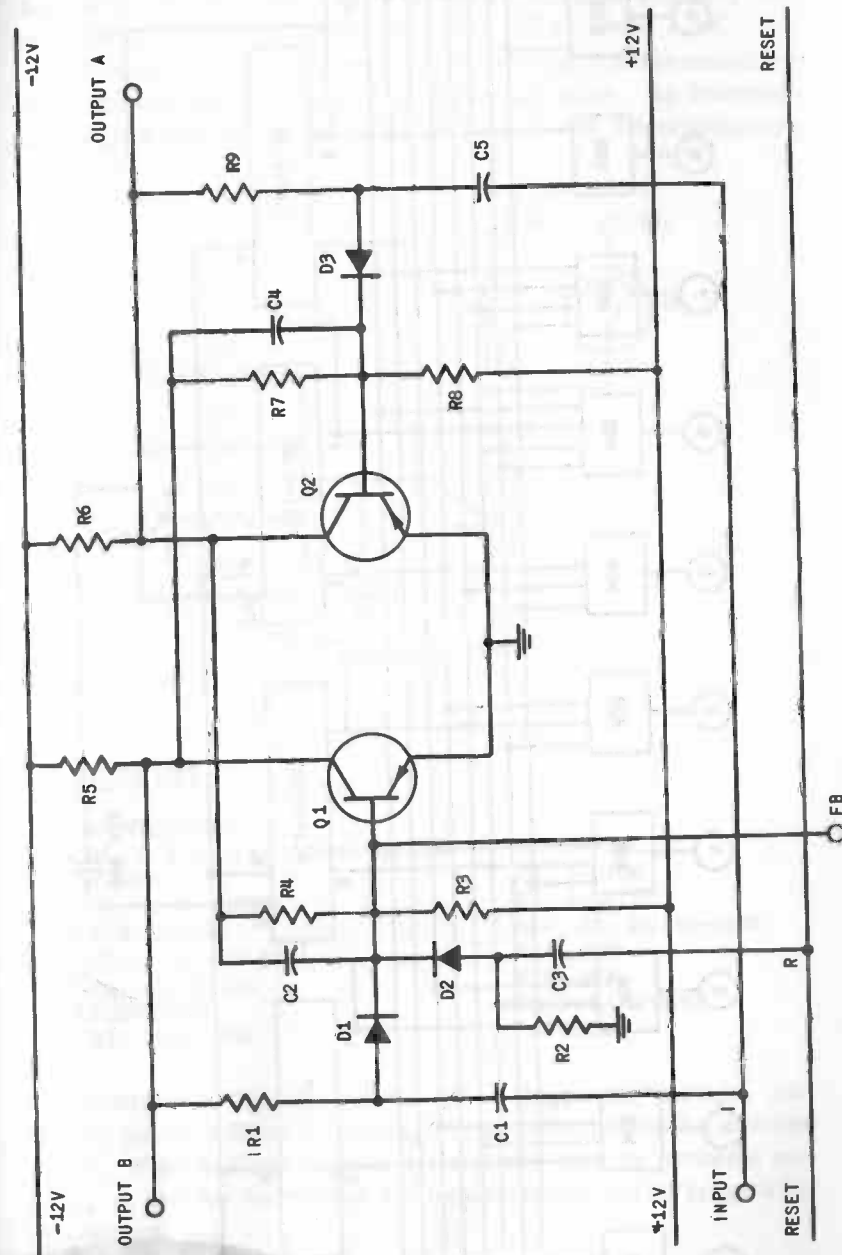
If we used a row of lights under the key numbers then, we could easily signal in binary code any number at all, using either 1s or 0s.

In computer work, a matrix is formed of many small ferrite doughnuts. A wire moves vertically through each doughnut and another moves horizontally through each, with a doughnut at each intersection. Another wire is threaded through each intersection diagonally. As you can see, applying a magnetizing voltage to any pair of vertical and horizontal wires will cause the doughnut at the intersection of those wires to magnetize. The third wire is used for resetting or demagnetizing. The computer itself then can store information in these doughnuts simply by determining whether or not they are magnetized, and reading out the information in the binary system.

## Decimal Counter

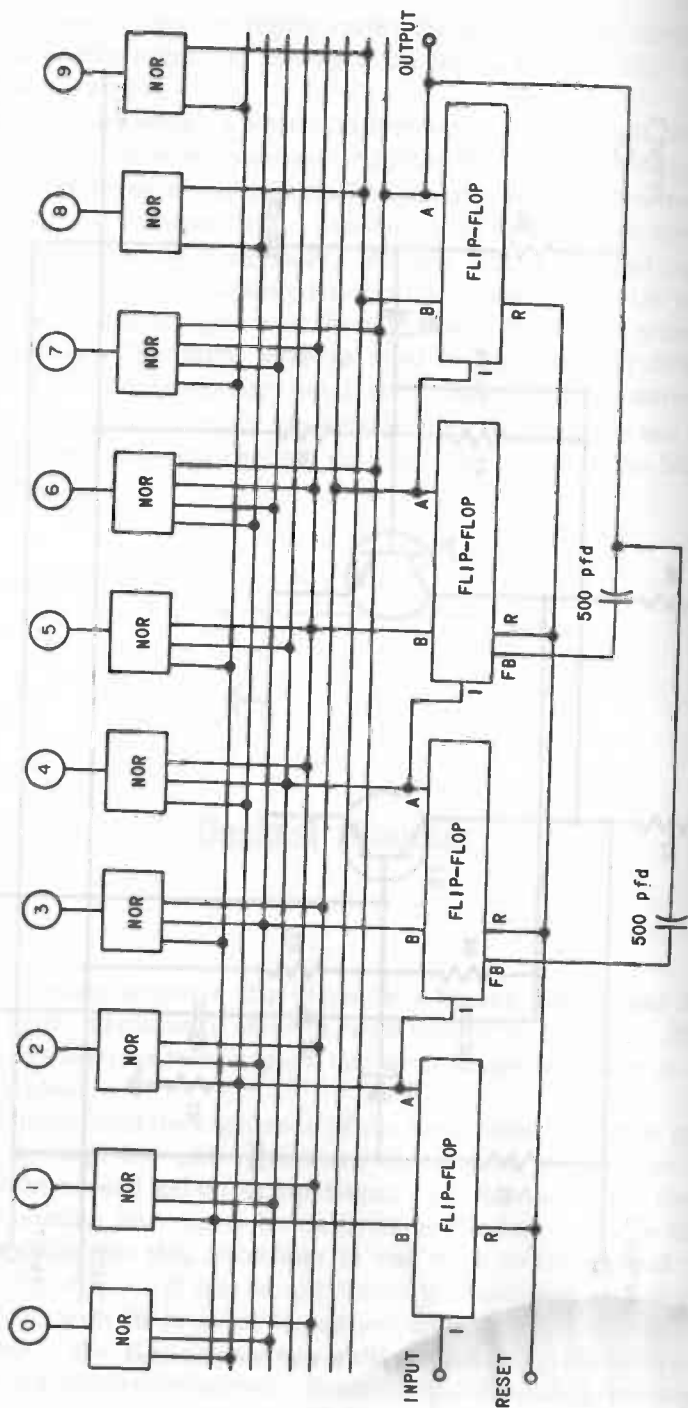
This system employs flip-flops in a binary count, and then uses logic circuits to convert from binary to decimal. NOR gates are used for this purpose and neon lamps are used in the 0-9 readout.

Feedback from the right side of the last output flip-flop goes back through 500-pfd capacitors directly to the base of the second and third flip-flops. The feedback in a decimal-counting unit must be delayed so the last stage is fully changed before this condition is fed back to the second and third flip-flops. If this is not done, the feedback signal will interfere with the original signal and cause a malfunction. In the DCU, the flip-flops have sufficient delay, therefore no additional delay is required. The maximum counting frequency



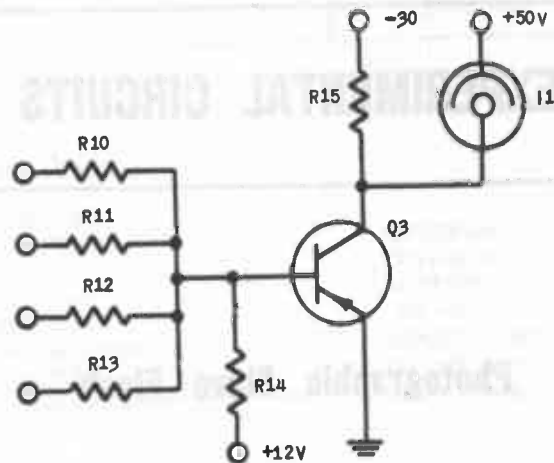
Courtesy: Texas Instruments





of the unit is about 200 kHz. It could be increased by lowering the values of the triggering capacitors to about 200 pfd, and reducing the steering resistors from 15K to about 3.9K.

The lowest operating temperature is chiefly determined by minimum hfe and the highest by maximum  $I_{cbo}$ . As transistor temperature increases, hfe increases and the transistors



#### PARTS LIST

##### TRANSISTORS:

Q1, 2, 3—use an appropriate type

##### DIODES:

D1, 2, 3—1N659

##### CAPACITORS:

C1, 3, 5—500 pfd

C2, 4—100 pfd

##### RESISTORS:

R1, 2, 9—15K

R3, 8—75K

R4, 7—10K

R5, 6—1.2K

R10, 11, 12, 13—22K

R14—68K

R15—31K

##### MISCELLANEOUS:

I1—NE-2

are saturated. This can call for more triggering voltage, and it may prove difficult to bring a transistor out of the storage mode. If such a redesign is attempted, and the problem occurs, it can be corrected by using larger value triggering capacitors.

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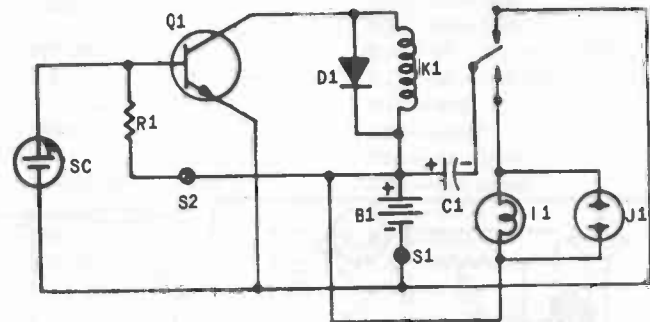
## EXPERIMENTAL CIRCUITS

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### Photographic Slave Flash

Any photographer can tell you that using a single light source produces shadows. However, if more than one flashbulb is used, how do you get them both to fire at the same time? The answer is a slave. When the flashbulb on the camera goes off, the photocell on the slave causes the slave to fire its lamp—at almost the same time, certainly close enough so the film will see it as light from two sources.

In this circuit, the light-sensitive photocell (SC) is triggered by the flash from the master unit. This current is then amplified by transistor Q1 and actuates relay RY. The relay then switches connections between B1 and C1. The capacitor, which had been collecting a charge from the battery, dumps its voltage across the socket, causing the flashbulb to go off. You can test the slave by closing S1 and observing I1. This circuit is more than adequate for use with conventional flashbulbs, but is not sufficiently fast for electronic flash equipment.



Courtesy: RCA

#### PARTS LIST

##### TRANSISTOR:

Q1—2N647

##### DIODE:

D1—1N34A

##### PHOTOCELL:

SC—photovoltaic cell

##### CAPACITOR:

C1—100 mfd electrolytic, 25v

##### RESISTOR:

R1—220K

##### BATTERY:

B1—22 1/2v

##### MISCELLANEOUS:

K1—5K relay

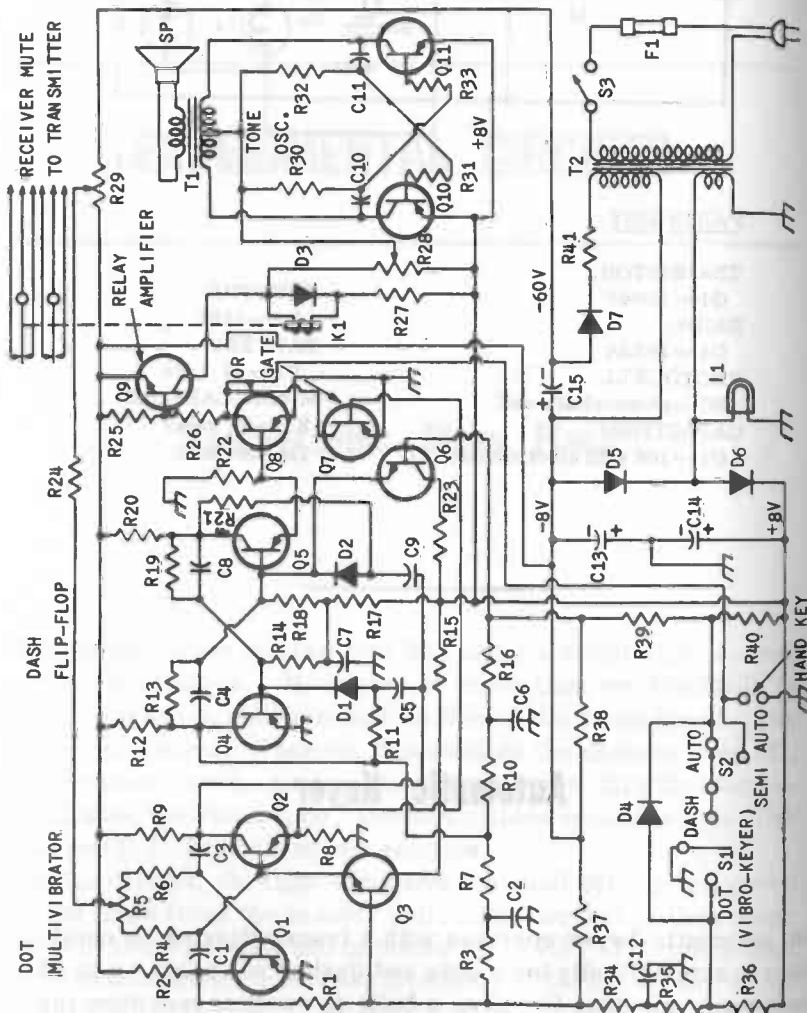
I1—24v bulb

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### Automatic Keyer

An automatic keyer operates with a transmitter or an oscillator to automatically form dots and dashes at speeds up to 60 words per minute. Usually, a built-in speaker monitors the transmissions. One important feature of this circuit is that characters are self-completing. That is to say, if you start to form a dash and release the key before the dash has been formed, the tone will continue until the dash is completed.

Breaking the circuit down to its component stages, you will find multivibrators, flip-flops or gates, and amplifiers.



Courtesy: RCA

## PARTS LIST

### TRANSISTORS:

Q1, 2, 4, 5, 7, 8, 10, 11—2N404  
 Q3, 6—2N1302  
 Q9—2N647

### DIODES:

D1, 2—1N34A  
 D3, 4, 5, 6—1N2858  
 D7—1N2861

### CAPACITORS:

C1, 3—1 mfd, paper (or Mylar), 200v  
 C2—0.47 mfd ceramic, 25v  
 C4, 8—560 pfd ceramic, 600v  
 C5, 9—330 pfd ceramic, 600v  
 C6, 7—0.01 mfd ceramic, 50v  
 C10, 11—0.02 mfd ceramic, 50v  
 C12—0.1 mfd ceramic, 50v  
 C13, 14—2000 mfd electrolytic, 15v  
 C15—16 mfd electrolytic, 150v

### RESISTORS:

R1—39K, 0.5w  
 R2, 9, 12, 20—3.9K  
 R3, 16—18K  
 R4, 6—51K  
 R5, 29—10K pot  
 R7, 10—22K  
 R8, 22—180 ohms

R11, 21—15K  
 R13, 19—33K  
 R14, 18, 30, 32—27K  
 R15, 23—270 ohms  
 R17—68K  
 R24—100K  
 R25—68 ohms  
 R26—560 ohms  
 R27—1.2K  
 R28—50K pot  
 R31, 33—10K  
 R34—6.8K  
 R35—8.2K  
 R36, 39, 40—15K  
 R37, 38—47K  
 R41—10K, 1w

### TRANSFORMERS:

T1—push-pull output transformer (14K to V.C.), Stancor #A3496, or equiv.  
 T2—power transformer, Stancor PS8415, PS8421 or equiv.

### MISCELLANEOUS:

K1—DC relay; coil resistance—2.5K; operating current—4 ma  
 F1—fuse, 1 amp  
 I1—indicator lamp #47  
 S1—Vibroplex keyer, or equiv.

These, applied in other configurations, can function separately or together in numerous applications. Relay K1 can be connected in such a way that when the key is in its active mode, the transmitter power is applied and receiver power is removed, muting the receiver. R28 functions as a volume control for the built-in loudspeaker which is driven by the push-pull audio amplifier formed by the final pair of 2N404 transistors.

## Electronic Theremin

The theremin is, perhaps, the original electronic musical instrument. It is "played" by hand movement in relation to two "antennas," one controlling pitch, the other volume. The accompanying schematic shows the basic oscillator circuits. The unit is placed behind an AM receiver which picks up the signals radiated by the antennas. If you want a completely independent musical instrument, all you need is a diode detector and audio amplifier.

L1 and L2 are Variloopsticks and the antennas are simple whips. The standard procedure is to have one antenna vertical,

### PARTS LIST

#### TRANSISTORS:

Q1—2N1097  
Q2, 3—2N1264

#### CAPACITORS:

C1, 2—200 pfd  
C3, 4—200 pfd trimmer  
C5, 6—.01 mfd

#### RESISTORS:

R1—180K  
R2, 3—51K

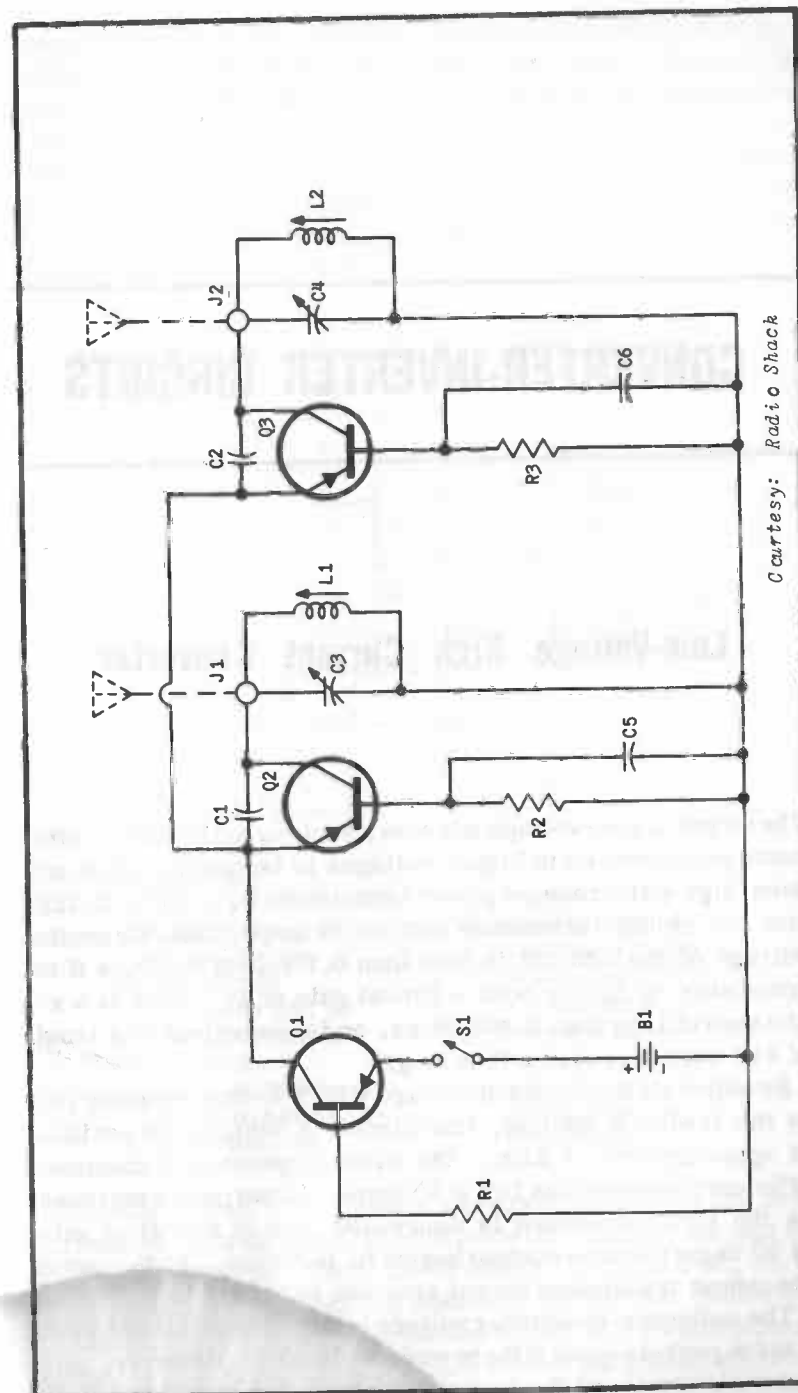
#### BATTERY:

B1—9v

#### COILS:

L1, 2—Variloopsticks

the other horizontal. With the unit behind an AM receiver and the loopstick cores screwed about half way in, tune the receiver near the center of the band and adjust the 200-pfd capacitor (C3) at J1 until a hissing noise is heard. Now adjust the other 200-pfd capacitor (C4) at J2 until a whistle comes through the speaker. Do not retune the receiver. Go back and reset C1 for the lowest pitch, and then start waving your hands around the antennas.





which would be 2.5 amps; therefore, the transistors are driven with a forced gain of 20 to 50 amps. At currents in excess of 50 amps, the transistors do not fully saturate, resulting in an efficiency loss. Probably the most important check in inverter or converter design is the area of load line traverses. The load line for this circuit was observed while operating at 50 amps. The safe area of operation of the 2N2728 is rectangular from 5 volts to 50 amps for switching applications.

## Frequency Stable 20-Watt Inverter 200-Watt 60-Hz Power Inverter

Designed to provide 115v AC from a 12v DC source, such as an automobile battery, these circuits are capable of operating mobile tape recorders, amplifiers, two-way radio gear, etc., requiring 20 (A) to 200 watts (B). Although not all equipment is frequency-sensitive, if a DC-to-AC inverter is to supply all types of mobile gear (synchronous motors, for example) it should have the means of controlling and holding the speci-

### PARTS LIST A

#### TRANSISTORS:

Q1, 2, 4—2N1372  
Q3—2N1038  
Q5—2N1302  
Q6, 7 —2N511A

#### DIODES:

D1—1N750A  
D2 to D5—1N2069

#### CAPACITORS:

C1—100 mfd, 15v  
C2—1 mfd

#### RESISTORS:

R1—2.15K

R2—422 ohms

R3—4.64K

R4—1.78K

R5—50-ohm pot

R6—1K pot

R7—5.62K

R8—42.2 ohms

R9—1K

R10—1 ohm, 2w

#### TRANSFORMERS:

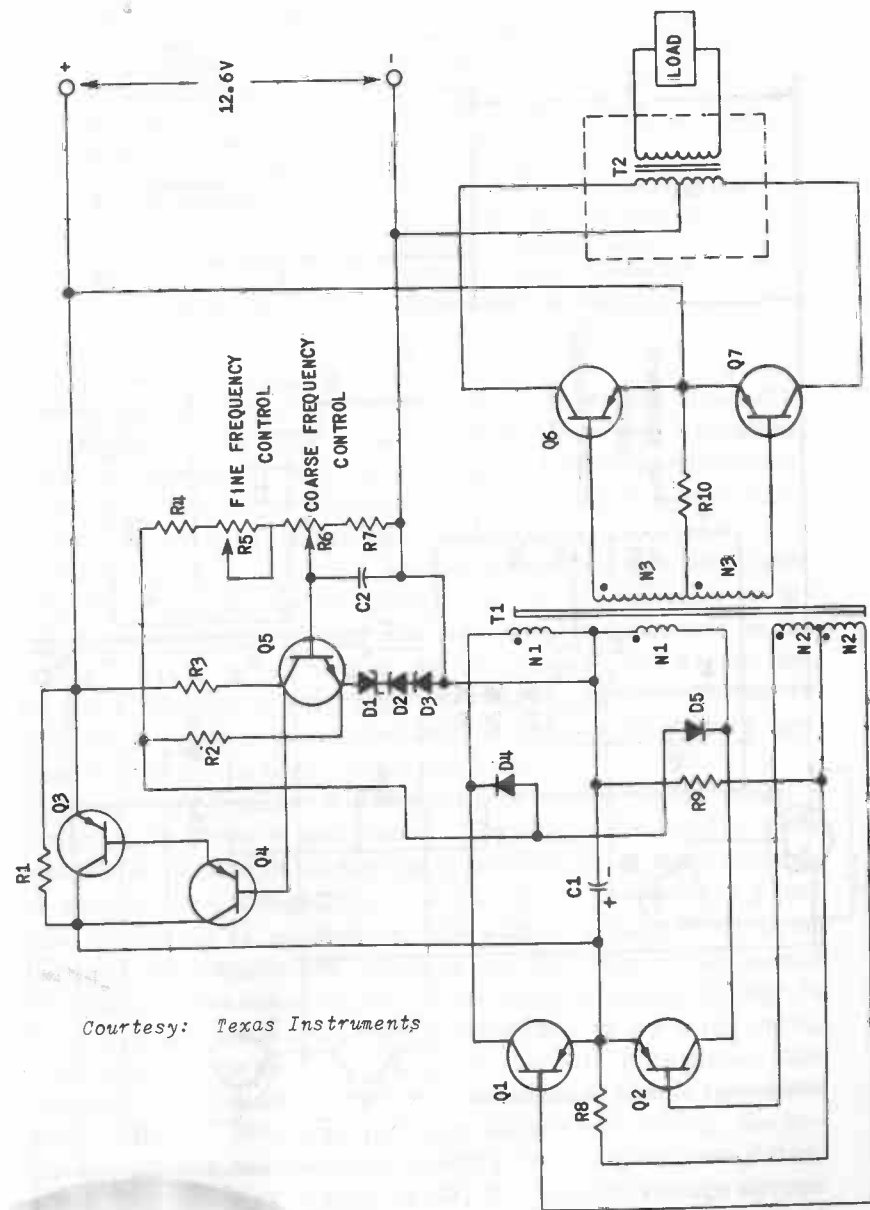
T1—Magnetics 50181-4A

N1—1200 turns #30 wire CT

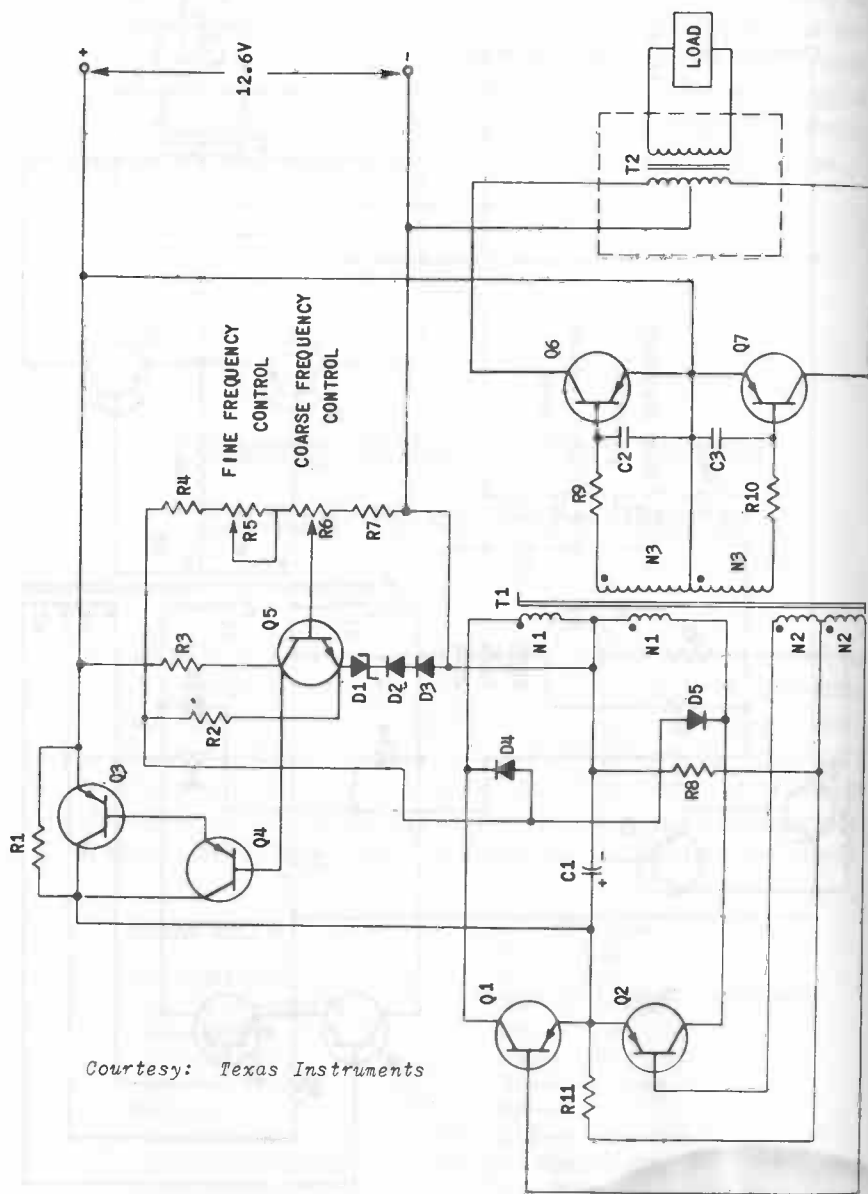
N2—150 turns #38 wire CT

N3—230 turns #26 wire CT

T2—power transformer



Courtesy: Texas Instruments



Courtesy: Texas Instruments

#### PARTS LIST B

##### TRANSISTORS:

- Q1, 2, 3—2N1038
- Q4—2N1372
- Q5—2N120
- Q6, 7—2N514A

##### DIODES:

- D1—1N751A
- D2 to D5—1N2069

##### CAPACITORS:

- C1—100 mfd, 15v
- C2, 3—4 mfd, 10v

##### RESISTORS:

- R1—100 ohms

R2—422 ohms

R3, 7—4.64K

R4—1.62K

R5—50-ohm pot

R6—1K pot

R8—1K

R9, 10—1 ohm, 5w

R11—42.2K

##### TRANSFORMERS:

T1—Arnold Eng'g. 3T-7189-D4

N1—320 turns #26 wire CT

N2—40 turns #36 wire CT

N3—80 turns #20 wire CT

T2—power transformer

fied frequency. Frequency stabilities of  $\pm 0.5\%$  are obtainable with these circuits. And, you'll find them to be much smaller, quieter, and more efficient than the familiar mechanical "chopper" or vibrator supplies that were used to power automobile radios many years ago.

These circuits are built around a square-core oscillator offering the following advantages: 1. The frequency is independent of the load, 2. the frequency is dependent on induced voltage, which we can readily control, and 3. the inherent efficiency is very high. A voltage regulator is incorporated as the frequency stabilizer, and power amplifiers are used to supply the high power required.

If you aren't familiar with square-core oscillators, the following may prove of assistance: The output of a square-core oscillator circuit is magnetically coupled to its input through a square-core transformer. If the circuit is oscillating and the transistor is conducting, the supply voltage is dropped across the transformer primary and the rate of flux change is linear. The changing flux in the core induces a voltage in the other coils in a magnitude proportional to the turns ratio. This biases one of the transistors on with a negative bias voltage, and biases the other transistor off with a positive bias voltage. When the core approaches saturation, the induced voltages are reduced, thereby reducing the base drive. Since the transistor is turning off, the induced voltage across the transformer winding is reversed, causing a reversal of bias, and therefore a reversal in the states of the oscillator transistors.

It should be pointed out that most equipment can't tell the difference between a square-wave and a sine-wave supply input. Where a true sine wave is required, adequate filtering will re-shape the output.

## Voltage Regulator

Here is a voltage regulator circuit providing an absolutely pure DC voltage from 22 to 30 volts, depending on the setting of potentiometer R9. It uses a 12-volt zener diode as a reference, assuring line regulation of  $\pm 1\%$  and load regulation within 0.5%. The circuit is designed for an input of 40-50v filtered DC.

### PARTS LIST

#### TRANSISTORS:

Q1—2N1479  
Q2, 3, 5, 7—2N3055  
Q4, 6—2N3053

#### DIODE:

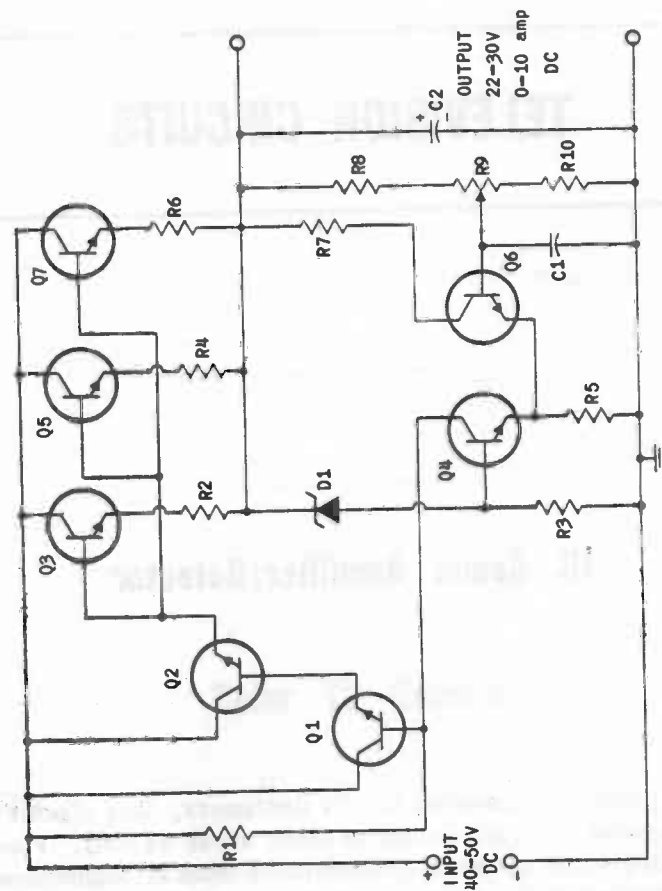
D1—12v Zener

#### CAPACITORS:

C1—1 mfd, paper, 25v  
C2—100 mfd electrolytic, 50v

#### RESISTORS:

R1—1.2K  
R2, 4, 6—0.1 ohm  
R3—2K  
R5—570 ohms  
R7—270 ohms  
R8, 10—1K  
R9—1K pot



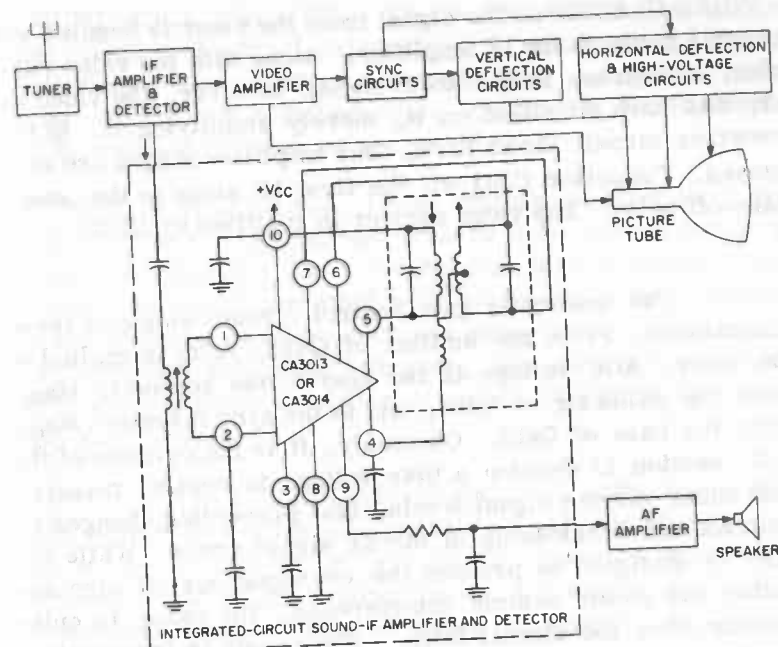
Courtesy: RCA



## TELEVISION CIRCUITS

### IC Sound Amplifier/Detector

While primarily intended for TV designers, this circuit has a million and one applications in other areas as well. Fundamentally, it is an audio preamplifier with straight-through amplification and no control functions. It can be used with crystal or ceramic phono cartridges, or with FM tuners. However, notice that the little box marked "amplifier" must be included between it and the loudspeaker. The input transformer is a 4.5-MHz interstage coupling unit, the other is a 4.5-MHz ratio detector transformer. Since the IC manufacturer's recommended component values should be used, a parts list is not included with this circuit.



Courtesy: RCA

### Color TV Receiver

To conclude this collection of solid-state circuits, here is a schematic of a transistorized color TV receiver and the complete parts list. (The tuner was omitted because of its highly specialized design and construction). These circuits amply illustrate the current state of the art in solid-state consumer product development in a competitive market (courtesy Texas Instruments). To help familiarize those not acquainted with these circuits, a brief description of the principal receiver functions follows.

**VIDEO IF STRIP:** The signal from the tuner is coupled via coaxial cable to the IF amplifier. Along with the video carrier, of course, is the audio signal; however, the video IF circuits have no effect on it, merely amplifying it. In the receiver circuit shown here, four amplifier stages are employed. Capacitor C301 off the first IF stage is the sound take-off point. The video carrier is rectified by D102.

**AGC:** The automatic gain control circuit employs three transistors. From the emitter of Q405, AGC is applied to the tuner. AGC voltage is fed also to the second IF stage, from the collector of Q404, and to the sync inverter stage, from the base of Q403. Obviously, it is the purpose of the AGC section to develop a bias voltage to control receiver gain under varying signal levels, thus preventing changes in contrast and overloading in strong signal areas. While the AGC is designed to prevent the consequences of airplane flutter and motor vehicle interference, its value is quite obvious when the circuit fails. The result is frequently a negative picture, with marked tearing and color interference.

**AUDIO:** The sound signal is picked-off the last video IF stage and fed to the base of Q301, the first audio IF amplifier. Two IF stages follow, then detection in the T301/D301-D302 circuitry. The ratio detector output is coupled to the first of three audio amplifier stages.

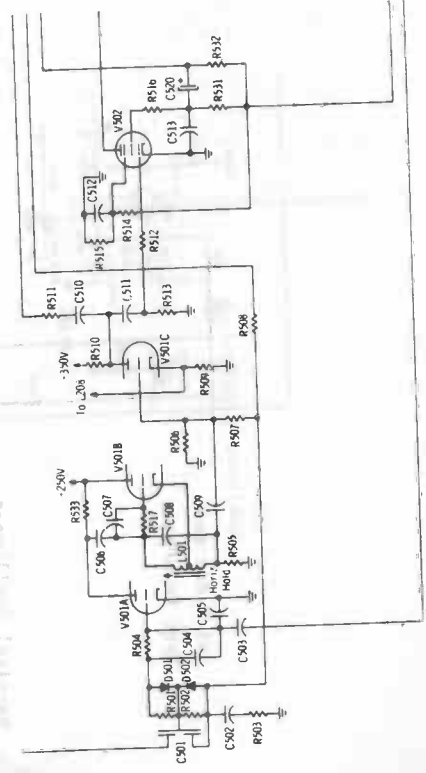
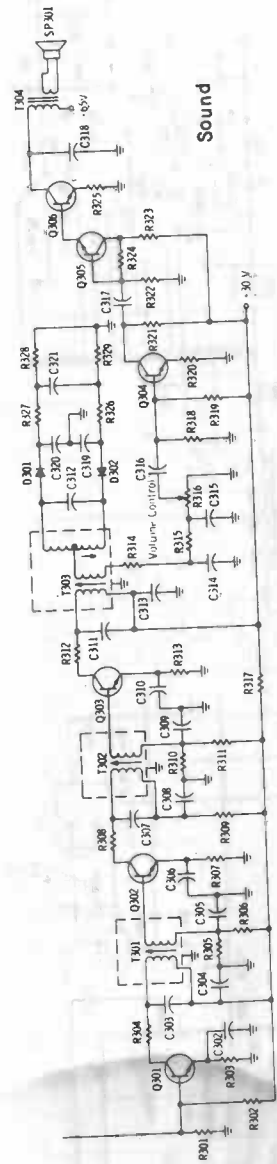
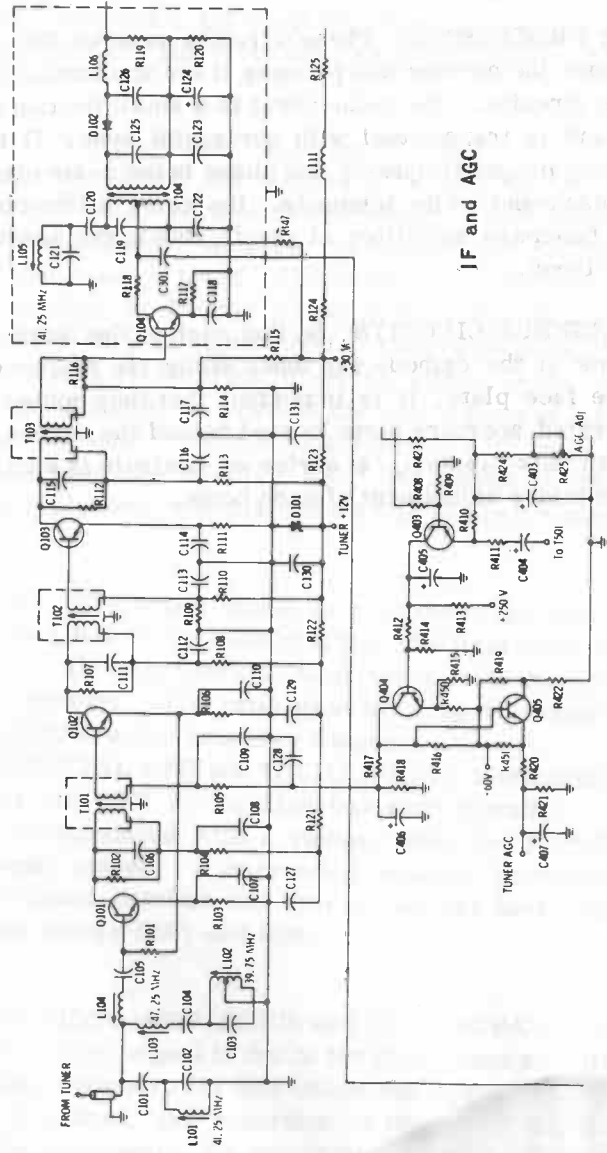
**HORIZONTAL AFC and OSCILLATOR:** Horizontal sync is coupled via C501 to the discriminator circuitry. The sync pulse is compared with a voltage spike fed back from the horizontal output. A correction voltage, corresponding to any deviation between the sync pulse and horizontal spike, appears across R501 and R502.

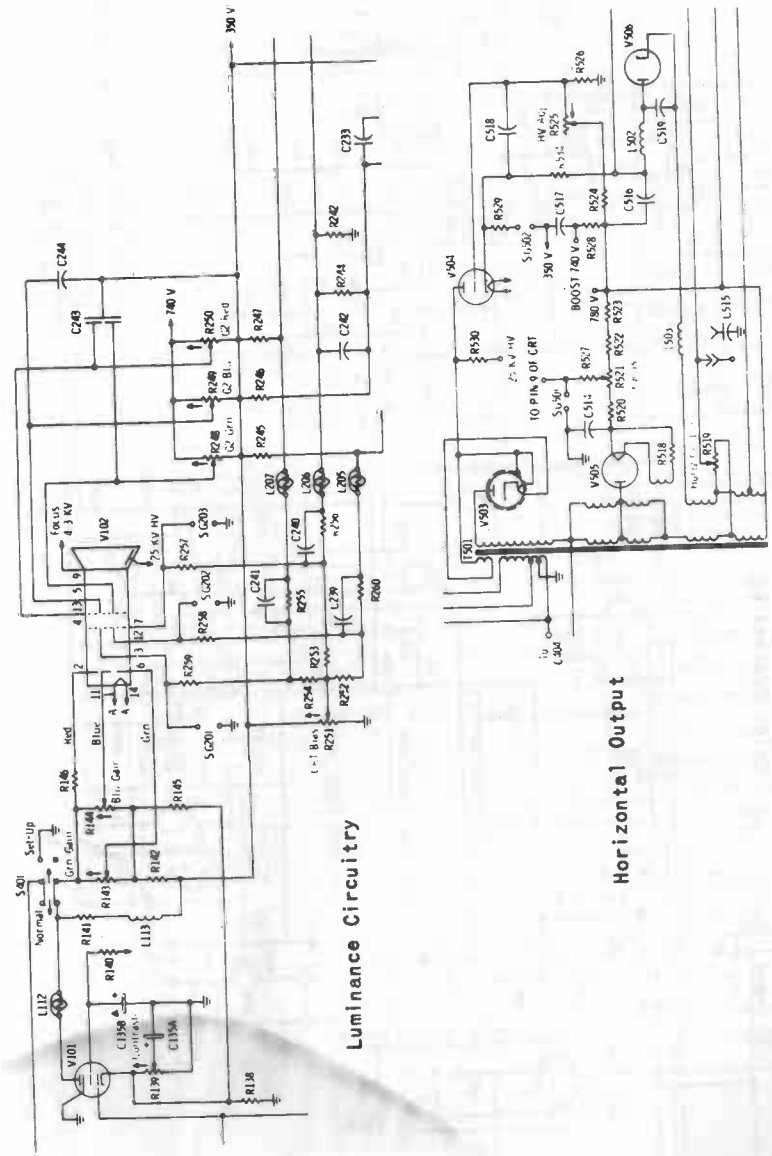
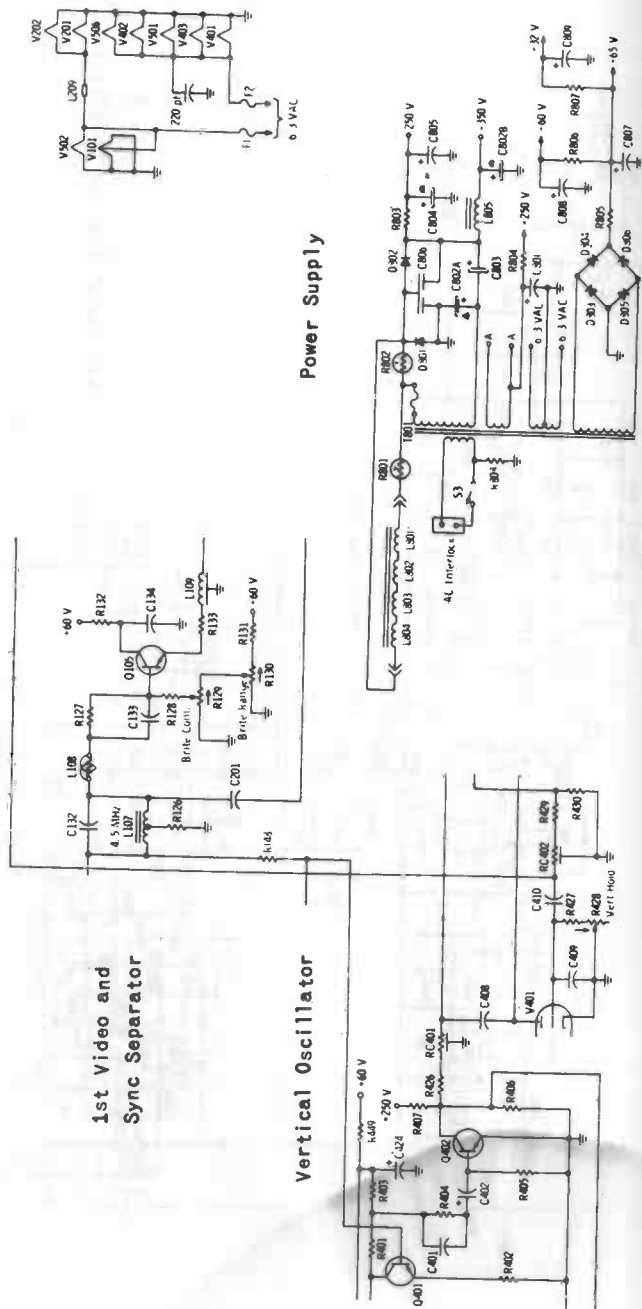
**FIRST VIDEO AMPLIFIER and SYNC SEPARATOR:** The rectified video signal is fed to the first video amplifier from the video detector. In this stage the video signal is amplified, of course, and a portion is tapped off and coupled to the sync separator. By appropriate biasing and circuit time constants, sync pulses are fed the vertical and horizontal oscillator circuits. V401 functions as the vertical oscillator.

**LUMINANCE CIRCUITS:** The luminance circuits amplify the "black-and-white" video signal to establish the correct brightness level during colorcasts and supply the entire video during B & W broadcasts. Color signals are coupled to the cathode ray tube screen grids.

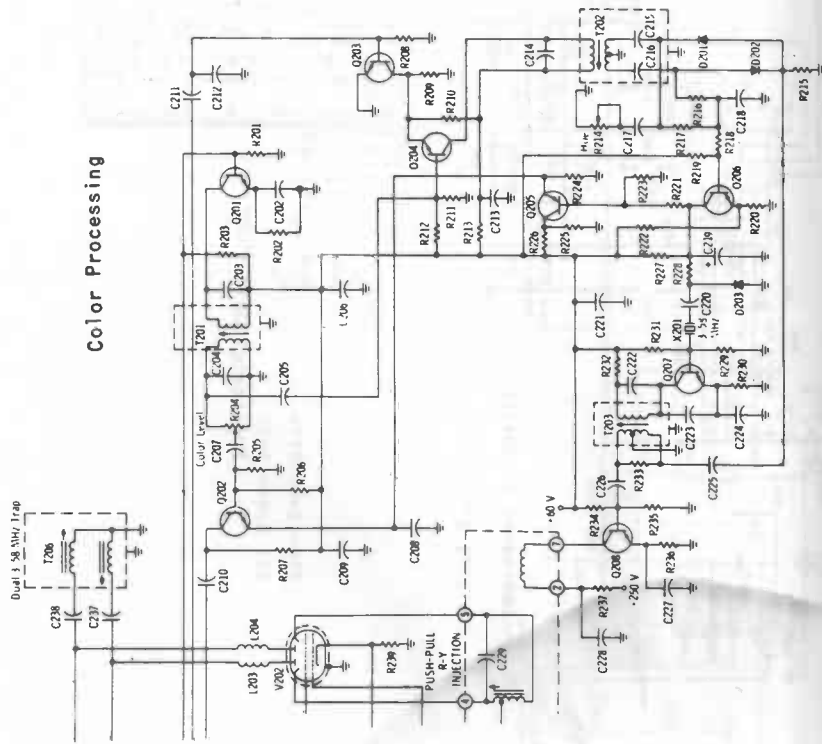
**COLOR PROCESSING:** These circuits remove the color signal from the carrier and process it for application to appropriate circuits. The color burst is a small portion of the carrier and is transmitted with horizontal sync. It is vital in achieving proper frequency and phase in the color circuits. During black-and-white telecasts, the color killer circuits hold the bandpass amplifier at cutoff, due to the absence of the color burst.

**CONVERGENCE CIRCUITS:** So that each of the three electron beams in the cathode ray tubes strike the proper color dot on the face plate, it is important that they converge at the perforated aperture plate located behind the screen. To accomplish this function, a series of controls is employed to achieve minor adjustment of each beam.

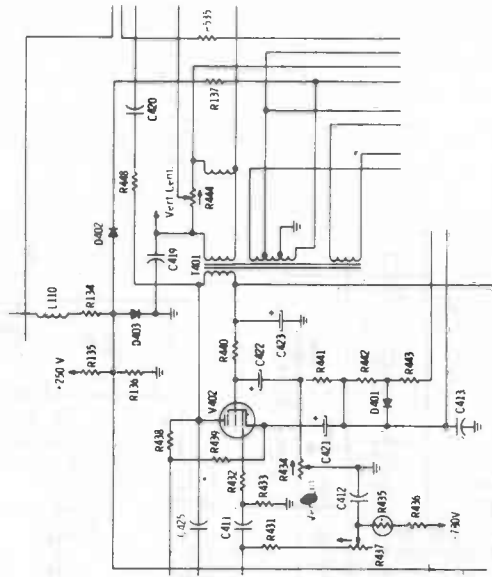




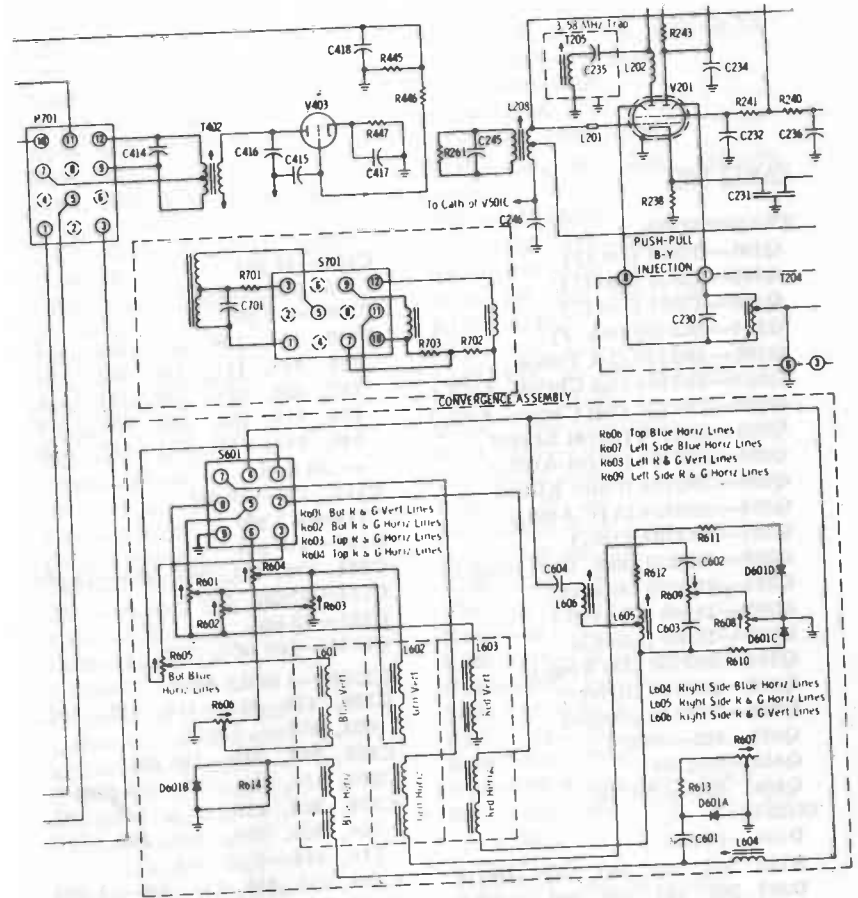
Color Processing



Vertical Output



Convergence Circuits



## PARTS LIST

### TRANSISTORS:

Q101—TIS57 (1st IF)  
Q102—TIS57 (2nd IF)  
Q103—TIS57 (3rd IF)  
Q104—SK5009 (4th IF)  
Q105—2N3704 (1st Video)  
Q201—2N3704 (1st Chrom. Amp.)  
Q202—2N3704 (2nd Chrom. Amp.)  
Q203—2N3704 (Burst Keyer)  
Q204—2N3704 (Burst Amp.)  
Q205—2N3704 (Color Killer)  
Q206—2N3704 (AFC Amp.)  
Q207—2N3704 (Osc.)  
Q208—SK6361 (Sub. Car. Amp.)  
Q301—2N4255 (Mixer)  
Q302—TI408 (IF Amp.)  
Q303—TI408 (Limiter)  
Q304—2N3708 (1st Amp.)  
Q305—2N3708 (Driver)  
Q306—TIP14A (Output)  
Q401, 402—SK6361  
Q403—2N3709  
Q404, 405—2N3710

DIODES:  
D101—1N759  
D102, 301, 302, 501, 502—1N914  
D201, 202, 401, 402, 403—1N295  
D203—TIV301  
D601A, B, C, D—Selenium Rect.  
D801, 802—1N2070  
D803, 804, 805, 806—1N2069

CAPACITORS:  
C101, 202, 220—22 pfd  
C102—47 pfd  
C103—59 pfd  
C104—16 pfd  
C105, 115—12 pfd  
C106—6.8 pfd  
C107, 108, 109, 110, 112, 113,  
114, 116, 117, 118, 122, 123,  
127, 128, 129, 130, 131, 133,  
134, 218, 232, 233, 236, 239,  
240, 241, 315, 511, 512, 513  
— .01 mfd  
C111, 126—10 pfd  
C119—5.6 pfd  
C120—1.8 pfd  
C121, 132, 201, 204, 223—56 pfd  
C124—5 mfd, 50v  
C125—18 pfd  
C135A—200 mfd, 25v  
C135B—4 mfd, 475v  
C136, 213, 411, 414, 417, 601,  
603, 801— .1 mfd  
C203, 207, 312—180 pfd  
C205, 314, 319, 320—820 pfd  
C206, 208, 209, 221, 227, 302,  
304, 305, 306, 308, 309, 310,  
313, 318—0.02 mfd  
C210, 215, 216, 244, 246—0.001  
mfd  
C211—320 pfd  
C212, 225—560 pfd  
C214—25 pfd  
C217—240 pfd  
C219, 316, 317, 402, 405—2  
mfd, 50v  
C222, 224, 229, 234—100 pfd  
C226—82 pfd

C228—0.1 mfd, 400v  
C230—85 pfd  
C231—2 x 0.0015 mfd  
C235, 237, 238—5 pfd  
C242, 514—150 pfd  
C243—2 x 0.001 mfd  
C245—36 pfd  
C301—3.3 pfd  
C303, 307—68 pfd  
C311—120 pfd  
C321—0.15 mfd  
C401—0.005 mfd  
C403, 404—2 mfd, 15v  
C406, 407—2 mfd, 10v  
C408, 420—0.033 mfd  
C409, 502, 504—0.0022 mfd  
C410—0.0082 mfd  
C412, 419, 425—0.01, 1000v  
C413—0.47 mfd  
C415, 416—0.0015 mfd  
C418—0.022 mfd  
C421—100 mfd, 50v  
C422—10 mfd, 475v  
C423—18 mfd, 475v  
C424—100 mfd, 75v  
C501—2 x 51 pfd  
C503—470 pfd  
C505—0.047 mfd  
C506—680 pfd  
C507—1500 pfd  
C508—0.0011 mfd  
C509—0.0047 mfd  
C510—0.001 mfd, 1KV  
C515—75 pfd  
C516—0.1 mfd, 1 KV  
C517—0.01 mfd, 1 KV  
C518—0.022 mfd, 600v  
C519—45 pfd, 5KV  
C520—40 mfd, 400v  
C602—0.082 mfd  
C604—0.056 mfd  
C701—100 pfd, 4KV  
C802A, 803—160 mfd, 250v  
C802B—80 mfd, 475v  
C804—100 mfd, 475v  
C805—0.001 mfd, 1KV  
C806—2 x 0.001 mfd  
C807—1000 mfd, 100v  
C808—150 mfd, 150v  
C809—250 mfd, 35v

RESISTORS:  
R101, 105, 230, 233, 236, 304,  
312, 317, 323, 432, 449, 503  
—1K  
R102, 257, 258, 259, 418—3.3K  
R103—240 ohms  
R104, 108, 113—270 ohms  
R106—430 ohms  
R107, 134, 146, 148, 326, 327,  
404—1.5K  
R109, 308—2K  
R110, 120, 261, 301, 302—8.2K  
R111, 138—390 ohms  
R112—620 ohms  
R114—1.6K  
R115, 211, 515—15K  
R116, 118, 121, 122, 147—22  
ohms  
R117—180 ohms  
R119, 223, 227—30K  
R123—330 ohms, 1w  
R124, 136, 208, 451—10K  
R125—2.4K  
R126, 409, 440—12K  
R127, 212, 504, 527—1 meg  
R128, 135—150K  
R129, 130—100K pot  
R131, 229—18K  
R132—680 ohms  
R133—1.2K, 1w  
R137—470 ohms  
R139—500 ohm pot  
R140—22K, 2w  
R141—7.5K, 5w  
R142—5K, 5w  
R143, 144—5K pot  
R145—22K, 5w  
R201, 322—6.2K  
R202, 213—470  
R203, 448—270K  
R204—1K (Color Level Pot.)  
R205, 315, 328, 329, 419, 422  
—6.8K  
R206—110K  
R207, 221, 506, 533—68K  
R209, 218, 309, 701—4.7K  
R210, 228, 234, 240, 241, 439,  
517—22K  
R214—1K (Hue Pot.)  
R215, 511—47K  
R216, 217, 255, 256, 260, 445,  
528—100K  
R219—4.7 meg  
R220—27

R222, 405—27K  
R224, 235, 318, 321—2.7K  
R225—39K  
R226, 416—20K  
R231—330K  
R232, 303, 417, 446—2.2K  
R235, 307, 313, 401—5.1K  
R237—15K, 2w  
R238, 239—270  
R242—39K, 2w  
R243—8.2K, 2w  
R244—4.7K, 2w  
R245, 247—18K, 3w  
R246—3.9K, 4w  
R248—1 meg (G2 Green Pot.)  
R249—1 meg (G2 Blue Pot.)  
R250—1 meg (G2 Red Pot.)  
R251—1 meg (CRT Bias Pot.)  
R252, 253, 254, 501, 502—470K  
R305, 310—11K  
R306, 311, 412—13K  
R314—120  
R316—10K (Vol. Pot.)  
R319—82K  
R320—33  
R324, 408, 429, 508—33K  
R325—30, 1w  
R402—1.2K  
R403—1.8K  
R406—43K  
R407—150K  
R410, 509, 512, 610, 611—100  
R411, 421—680  
R413, 535, 804—220K  
R414—5K  
R415—300  
R420, 424—750  
R423—5.1K, 1w  
R425—500 (AGC Adj. Pot.)  
R426, 430—82K  
R427, 438—330K  
R428—750K (Vert. Hold Pot.)  
R431, 507, 808—1.5 meg  
R433, 436—2.2 meg  
R434—1.5K (Vert. Lin. Pot.)  
R435, 802—Thermistor  
R437—4 meg (Vert. Size Pot.)  
R441—4.7K, 1w  
R442, 702, 703—220  
R443—270, 1w  
R444—10, 2w (Vert. Cent. Pot.)  
R447—3.9K  
R450—9.1K

R505—6.8K, 1w  
R510—82K, 1w  
R513—10 meg  
R514—100K, 2w  
R516—820K, 1w  
R518—3.9  
R519—10 (Horiz. Centering Pot.)  
R520—2.2 meg, 2w  
R521—10 meg (Focus Pot.)  
R522, 523—18 meg, 2w  
R524—2 meg, 1w 5%  
R525—1 meg (Hv. Adj. Pot.)  
R526—1.5 meg, 1w 5%  
R529—1K, 1w  
R530—1.5K, 1w  
R531—10K, 5w  
R532—680, 3w  
R534—1K 5%  
R601, 606—60 (Pot.)  
R602, 603, 604, 605—120 (Pot.)  
R607—120 (Pot.)  
R608—70 (Pot.)  
R609—60 (Pot.)  
R612, 614—82, 1w  
R613—68, 1w  
R801—Varistor  
R803—3.5K, 10w  
R805—10, 2w  
R806—82  
R807—350, 10w

#### COILS:

L101, 105—41.25 MHz Trap  
L102—39.75 MHz Trap  
L103—47.25 MHz Trap  
L104—1.1  $\mu$ h S.T. Coil  
L106—10  $\mu$ h  
L107—4.5 MHz Trap  
L108—268  $\mu$ h & 15K  
L109—Delay Line  
L110—Peaking Coil  
L111—1 mh  
L112—220  $\mu$ h & 12K  
L113—550  $\mu$ h  
L201, 209—Ferrite Sleeve  
L202, 203, 204—18  $\mu$ h  
L205, 206, 207—696  $\mu$ h shunted  
by 22K  
L208—2nd Chroma Amp. Load  
L501—Horiz. Osc. Inductor  
L502, 503—Damper Choke  
L601—Blue Convergence Yoke  
L602—Green Convergence Yoke  
L603—Red Convergence Yoke

L604—Right Side Blue Horiz. Line  
L605—Right Side R & G Horiz.  
Lines  
L606—Right Side R & G Vert.  
Lines  
L801, 802, 803, 804—Degaussing  
Coils  
L805—Filter Choke  
TRANSFORMERS:  
T101—1st Video IF  
T102—2nd Video IF  
T103—3rd Video IF  
T104—4th Video IF  
T201—Chroma Bandpass  
T202—Burst Tank  
T203—Osc. Tank  
T204—Quad Trans.  
T205—3.58 MHz Trap  
T206—Dual 3.58 MHz Trap  
T301—1st Sound IF  
T302—2nd Sound IF  
T303—Discrim.  
T304—Output  
T401—Vert. Out.  
T402—Pincushion Correct.  
T501—Horiz. Out.

T801—Power  
MISCELLANEOUS:  
V101—12GN7A ("Y" Amp.)  
V201—6JH8 (B-Y Demod.)  
V202—6JH8 (R-Y Demod.)  
V401—6BA11 (Vert. Osc.)  
V402—6HE5 (Vert. Out.)  
V403—6C4 (Pincushion Correct.)  
V501A—1/3 6U10 (Horiz. Control)  
V501B—1/3 6U10 (Horiz. Osc.)  
V501C—1/3 6U10 (Horiz. Disch.)  
V502—6JS6 (Horiz. Output)  
V503—3AT2 (HV Rect.)  
V504—6BK4 (Volt. Reg.)  
V505—IV2 (Focus Rect.)  
V506—6DW4 (Damper)  
X201—3.579545 MHz Crystal  
SG1, 2, 3—Spark Gap  
SP301—3.2 (Speaker)  
RC401, 402—RC Integrator  
S401—Setup Switch  
S601—Convergence Socket  
S701—Yoke Socket  
P601—Convergence Plug & Cable  
Assy.  
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