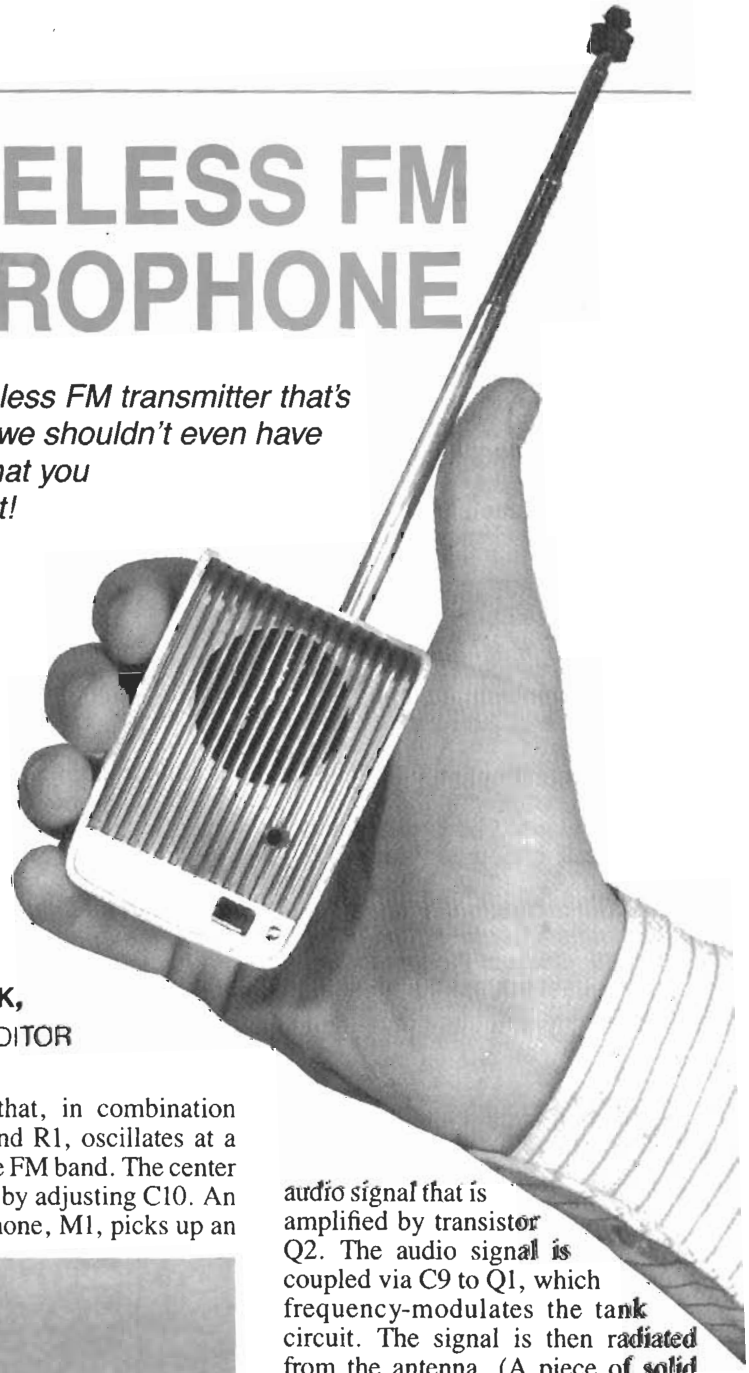
WIRELESS FM MICROPHONE

Here's a wireless FM transmitter that's so versatile, we shouldn't even have to tell you what you can do with it!



MARC SPIWAK,
ASSOCIATE EDITOR

OUR BATTERY-POWERED WIRELESS FM transmitter that can transmit an audio signal over a short distance (about a hundred feet), to any frequency in the standard FM band. The transmitter itself is assembled on a PC board that measures less than 4 square inches (34 × 46 millimeters). The fully assembled unit is shown in Fig. 1.

The transmitter conforms to the FCC's regulations regarding wireless microphones. Its emissions stay within a band of 200-kHz, and its output is between 88 and 108 MHz. The field strength of the radiated emissions do not exceed 50 μV/m at a distance of 15 meters from the device.

The small size of the transmitter is what gives it its versatility. The transmitter can be used as a wireless microphone, it can be concealed in a room and used a "bug" for a good practical joke, or perhaps placed near a baby's crib and used as a child monitor. The wireless microphone in Fig. 2 used the case of an old microphone that was found in a junkbox. A small on/off switch was added to the circuit. It can be used to talk to someone in another car on a long road trip, or to anyone wearing a walkman-type radio.

The circuit

The schematic for the transmitter circuit is shown in Fig. 3. Adjustable-capacitor, C10, and the coil, L1, form a tank circuit that, in combination with Q1, C2, and R1, oscillates at a frequency on the FM band. The center frequency is set by adjusting C10. An electret microphone, M1, picks up an audio signal that is amplified by transistor Q2. The audio signal is coupled via C9 to Q1, which frequency-modulates the tank circuit. The signal is then radiated from the antenna. (A piece of solid wire can be used as an antenna if you don't want to use a telescopic one.)

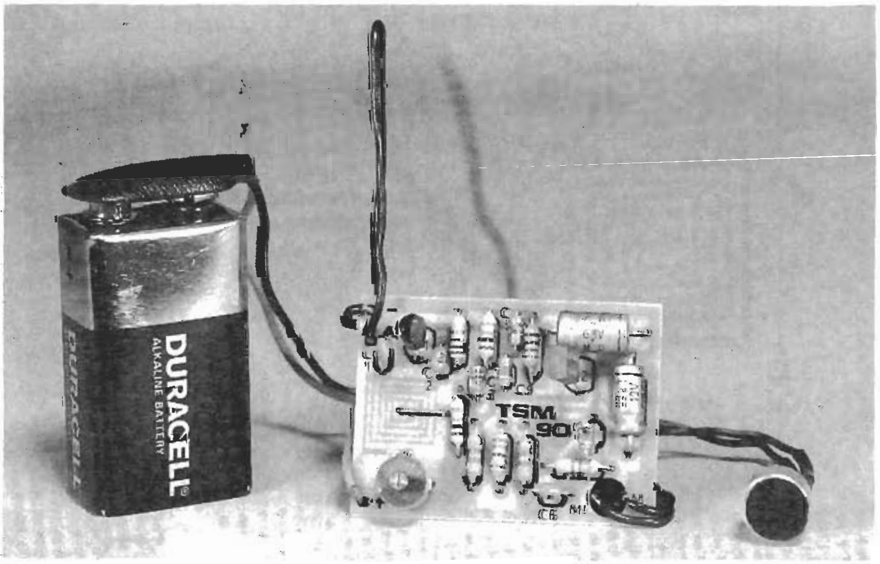


FIG. 1—THE FULLY ASSEMBLED PC BOARD. This FM transmitter board is so small, measuring $1\frac{5}{16} \times 1\frac{13}{16}$ inches, that it will fit inside almost anything.

The circuit can operate from 9–12 volts DC. It's easiest to use an ordinary 9-volt transistor battery, but if you have to conserve space in a small case, you may prefer to use small 12-volt batteries that are about half the size of a AA cell. If you are going to use the transmitter as a child monitor or for some other similar application, you may want to use an AC adapter as a power source.

Parts

All of the parts, including an etched, drilled, and silk-screened PC

PARTS LIST

All resistors are ¼-watt, 5%, unless otherwise noted.

R1—100 ohms

R2, R4—10,000 ohms

R3—1000 ohms

R5, R7—47,000 ohms

R6—2.2 megohms

R8—4700 ohms

Capacitors

C1—1.5 pF, ceramic disc

C2—100 pF, NPO

C3, C4—330 pF, NPO

C5, C9—0.1 µF, NPO

C6—0.001 µF, NPO

C7—22 µF, electrolytic

C8—6.8 µF, electrolytic

C10—10–40 pF trimmer capacitor

Semiconductors

Q1—BF199 or NTE229, or equivalent NPN transistor

Q2—BC183C or NTE199, or equivalent NPN transistor

Other components

L1—coil, approximately 1 µH (see text)

M1—electret microphone

S1—SPST switch

Miscellaneous: 9-volt battery and connector, wire, project case, solder, etc.

Note: The complete TSM kit for the FM transmitter is available for $13.85. Contact Prospect Electronics, PO Box 9144, Allentown, PA 18105.

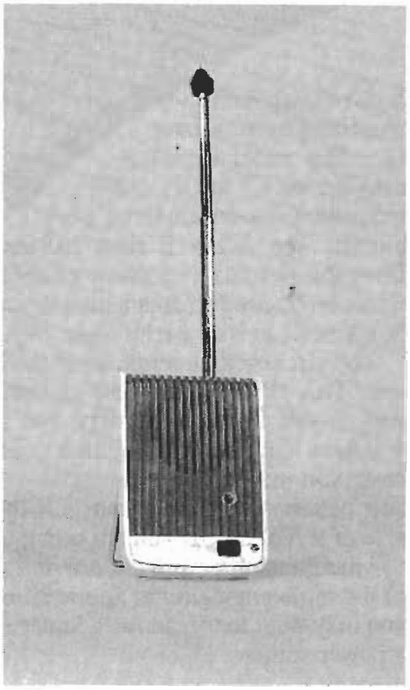


FIG. 2—THIS WIRELESS MICROPHONE was made out of an old, gutted microphone. A transmitter and a 9-volt battery fit inside.

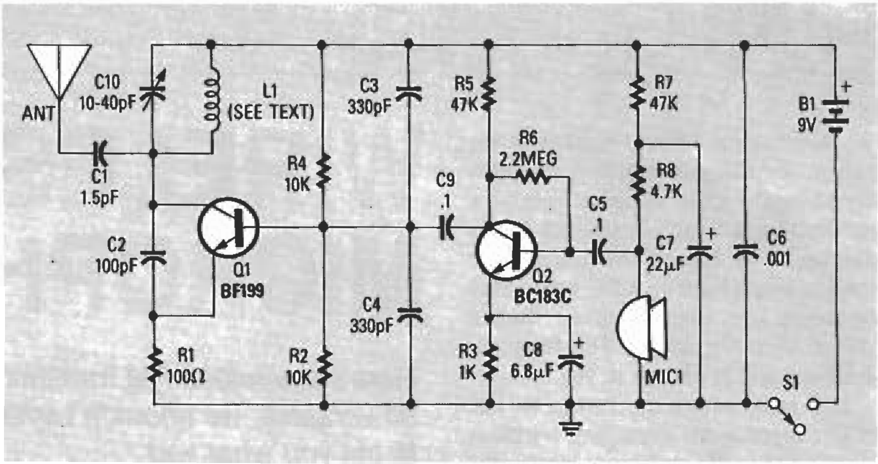


FIG. 3—THE FM-TRANSMITTER circuit has few components, but it can still transmit a clear audio signal up to a hundred feet.

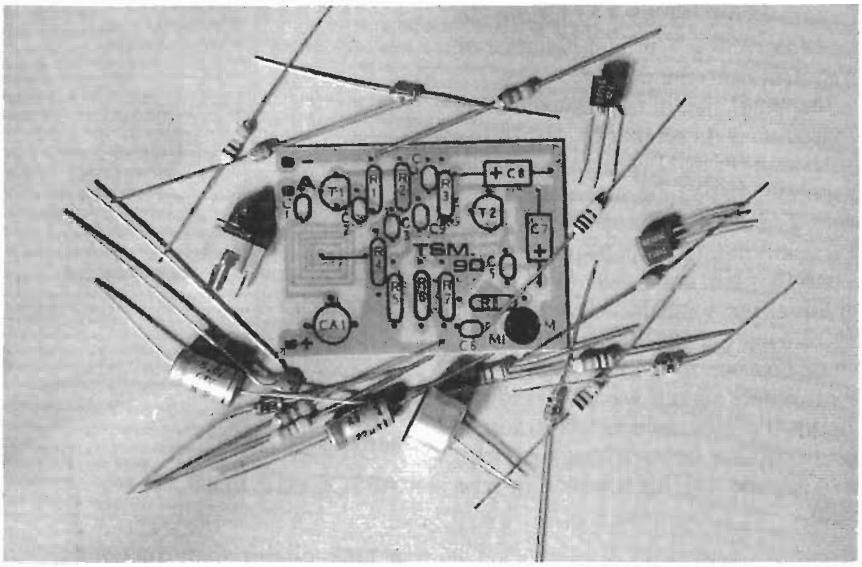


FIG. 4—HERE IS THE COMPLETE PARTS KIT. You shouldn't have any trouble building this one, and it's sure to work when finished.

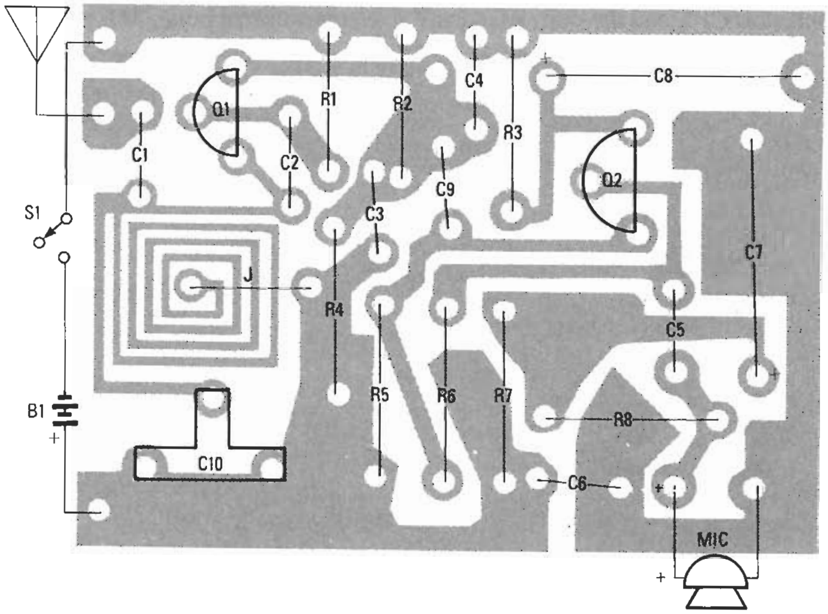
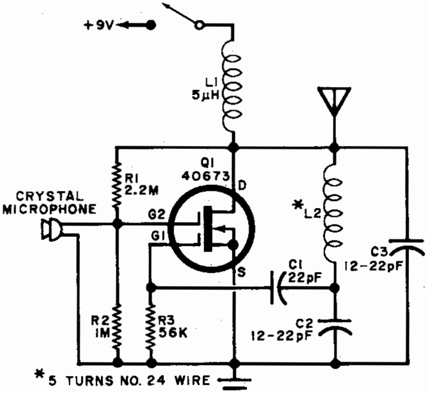


FIG. 5—PARTS-PLACEMENT DIAGRAM. Solder the components to the board in the order of the Parts List.

Another Wireless Microphone

Q. *In the Hobby Scene for July 1980, you showed a three-transistor vhf wireless microphone. May I suggest a simple, single-transistor vhf wireless microphone?—R. Perrigo, Merseyside, Liverpool, U.K.*

A. Thank you very much for your suggestion, which is shown schematically in the accompanying figure. I'm sure many readers will want to experiment with the circuit. Although you have not stated so explicitly, seemingly a short length of solid copper wire should be used for the antenna and the values of *C2* and *C3* chosen for the desired transmitting frequency. Some adjustment of the operating frequency is possible by increasing or decreasing the pitch of the winding comprising *L2*. The circuit can be powered by a 9-volt transistor battery.



Communications
Canada

RSS-214
ISSUE 1

RADIO STANDARDS SPECIFICATION

LOW-POWER WIRELESS MICROPHONES AND TELEMETERING DEVICES FOR ONE-WAY COMMUNICATION OPERATING IN THE FM BROADCASTING BAND 88-108 MHz

EFFECTIVE DATE: OCTOBER 31, 1974

RELEASE DATE: OCTOBER 31, 1974

TELECOMMUNICATION REGULATORY SERVICE

LOW-POWER WIRELESS MICROPHONES AND TELEMETERING DEVICES

FOR ONE-WAY COMMUNICATION

OPERATING IN THE FM BROADCASTING BAND 88 - 108 MHz

1.0 INTENT

1.1 This Specification sets forth the minimum standards required for the type-approval of low-power wireless microphone and telemetering equipment described by the above Specification title.

1.2 Equipment approved under this Specification is exempted from licensing as provided for in the General Radio Regulations Part II Section 6, Subsection (1), Paragraph (k).

2.0 GENERAL

2.1 Those seeking approval of equipment under this Specification shall satisfy the Department at their own expense that the equipment actually meets the requirements of this Specification.

2.2 Notwithstanding the fact that a particular type of equipment meets the requirements of this Specification, the Department reserves the right to require that adjustments be made to that equipment, to the satisfaction of the Department, or to suspend operation wherever it causes interference within the meaning of the Radio Act.

2.3 The Department reserves the right to revise this Specification.

3.0 RELATED DOCUMENTS

3.1 Radio Standards Procedure 100 - Procedure to Obtain Type-Approval of Radio Equipment.

4.0 EQUIPMENT REQUIREMENTS

4.1 Equipment Identification - The following information shall be permanently displayed on the transmitter: (a) Type-Approval number, (b) Manufacturer's name, (c) Model identification.

4.2 Antenna - only the antenna supplied with the transmitter may be used.

4.3 Microphone or Transducer - only the microphone, transducer(s) and associated cable as supplied or specified by the manufacturer may be used. In the case of the wireless microphone, the microphone unit shall be either (a) incorporated in the same enclosure with the transmitter chassis or (b) permanently attached to the transmitter chassis via cable. Only configuration (a) or (b) is permissible.

4.4 Kits - Kits may be accepted if it can be shown that the kit is:

(a) complete and includes all essential accessories, e.g. microphone, antenna, etc. and

(b) factory-assembled to the extent that when the assembly is completed the unit will meet the minimum technical requirements of this Specification.

5.0 STANDARD TEST CONDITIONS

5.1 Definition - Standard Test Conditions are those conditions under which the transmitter shall be operated while it is being tested for minimum requirements. These conditions shall apply at all times unless otherwise specified.

5.2 Test Voltage

5.2.1 If an external power source is used, the test voltage at the power input terminals shall be within 2% of the working voltage as stated by the manufacturer.

5.2.2 Where a self-contained battery (batteries) is the primary or sole power source for normal operation of the equipment, the type-approval test shall be made under the following conditions:

(a) The battery (batteries) shall be the same type as normally used in the equipment; and

(b) The battery (batteries) shall be in a fully charged condition at the outset of testing.

5.3 Field Strength Measurement Correction Factor - for equipment normally hand held or worn on the body.

5.3.1 If the radiation field of the fundamental from this equipment is reduced during normal usage (as compared to the reading obtained under test), then all field strength measurements shall be reduced by 4db (i.e. multiplied by 0.63).

6.0 FIELD STRENGTH MEASUREMENT TEST SITE

6.1 The test site shall be such that r.f. background noise levels are low and the effects of absorption and reflection of r.f. energy are negligible. The site shall be substantially flat over an area having a radius of approximately 100 metres (328 feet) and shall not have more than a gentle slope in any direction for several times this distance. The site shall be free from buildings, tall trees, wire fences, buried metal conductors, small bodies of water, and other objects capable of reflecting r.f. energy. The noise level at the site shall be checked with a field strength meter to ensure that high levels of radio-frequency energy from extraneous sources will not prohibit the performance of the field strength measurement.

7.0 WIRELESS MICROPHONE

7.1 R.F. Power-Fundamental Output

7.1.1 Definition - The r.f. power output is defined in terms of the maximum radiated field strength as determined under the following conditions of measurement:

7.1.2 Equipment Set-Up - The transmitter shall be set up (in a manner similar to the sketch shown in Figure 1a) in a vertical position on a non-conducting rotatable platform. There shall be no reflective objects within 30 metres (100 feet) of "A" or "B". The transmitter shall be unmodulated and controls shall be adjusted for maximum r.f. output.

7.1.3 Method of Measurement - The platform shall be rotated through 360° and the dipole of the field intensity meter (FIM) shall be oriented in all planes of polarization to determine the maximum field strength of the emission which shall be measured and recorded.

7.1.4 Minimum Standard - The corrected field strength of the fundamental shall not exceed 50 microvolts per metre at 15 metres (50 feet) distance, (see para. 5.3)

7.1.5 Optional Method - If extraneous noise or signals make it difficult to make measurement, the distance between "A" and "B" may be reduced to 3 metres (10 feet) as shown in Figure 1b.

7.1.6 Minimum Standard - The corrected field strength of the fundamental shall not exceed 250 microvolts per metre at 3 metres (10 feet). See Para. 5.3)

7.2 Spurious Output

7.2.1 Definition - Any emission from the unmodulated transmitter at frequencies which are outside the 200 kHz band centered on the operating frequency.

7.2.2 Equipment Set-Up - The transmitter shall be set up (in a manner similar to Figure 1b) in its vertical position on a non-conducting rotatable platform. The transmitter shall be unmodulated and operator controls shall be set for maximum r.f. output.

7.2.3 Method of Measurement - The method of measurement shall be similar to that of paragraph 7.1.3. The output spectrum shall be scanned using the FIM from the lowest frequency generated in the device up to 1000 MHz and the field strength levels of all spurious outputs shall be measured and noted.

7.2.4 Minimum Standard - The corrected field strength of any spurious emission shall not exceed 40 microvolts per metre at a distance of 3 metres (10 feet). (See para. 5.3)

7.3 Transmitter Tuning Range

7.3.1 Definition - The transmitter tuning range is the band of frequency extremes within which the transmitter fundamental output must operate.

7.3.2 Method of Measurement - The transmitter shall be turned on and allowed to warm up for a period of 1 minute. The transmitter shall be tuned over its maximum range and the lowest and highest tuned frequencies of operation shall be measured.

7.3.3 Minimum Standard - The frequency of the fundamental output shall not be less than 88.1 MHz nor more than 107.9 MHz.

8.0 TELEMETERING DEVICE

8.1 R.F. Power-Fundamental Output

8.1.1 Definition - The r.f. power output is defined in terms of the maximum radiated field strength as determined under the following conditions of measurement;

8.1.2 Equipment Set-Up - The transmitter shall be set up (in a manner similar to the sketch shown in Figure 1a) in a vertical position on a non-conducting rotatable platform. There shall be no reflective objects within 30 metres (100 feet) of "A" or "B". Operator controls shall be adjusted for maximum r.f. output. Tests shall be performed with each type of sensor device connected to the transmitter.

8.1.3 Method of Measurement - The platform shall be rotated through 360° and the dipole of the field intensity meter (FIM) shall be oriented in all the planes of polarization to determine the maximum field strength of the emission which shall be measured and recorded.

8.1.4 Minimum Standard - The corrected field strength of the fundamental shall not exceed 50 microvolts per metre at 15 metres (50 feet) distance. (See para. 5.3)

8.1.5 Optional Method - If extraneous noise or signals make it difficult to make measurement, the distance between "A" and"B" may be reduced to 3 metres (10 feet), as shown in Fig. 1b.

8.1.6 Minimum Standard - The corrected field strength of the fundamental shall not exceed 250 microvolts per metre at 3 metres (10 feet), (See para. 5.3)

8.2 Spurious Output

8.2.1 Definition- Any emission from the transmitter at frequencies which are outside the 200 kHz band centered on the operating frequency.

8.2.2 Equipment Set-Up - The transmitter shall be set up (in a manner similar to Fig. 1b) in a vertical position on a non-conducting rotatable platform. Operator controls shall be adjusted for maximum r.f. output.

8.2.3 Method of Measurement - The method of measurement shall be similar to that of paragraph 8.1.3. The output spectrum shall be scanned using the FIM from the lowest frequency generated in the device up to 1000 MHz and the field strength levels of all spurious outputs shall be measured and noted.

8.2.4 Minimum Standard - The corrected field strength of any spurious emission shall not exceed 40 microvolts per metre at a distance of 3 metres (10 feet) (see para. 5.3)

8.3 Transmitter Tuning Range

8.3.1 Definition - The transmitter tuning range is the band of frequency extremes within which the transmitter fundamental output must operate.

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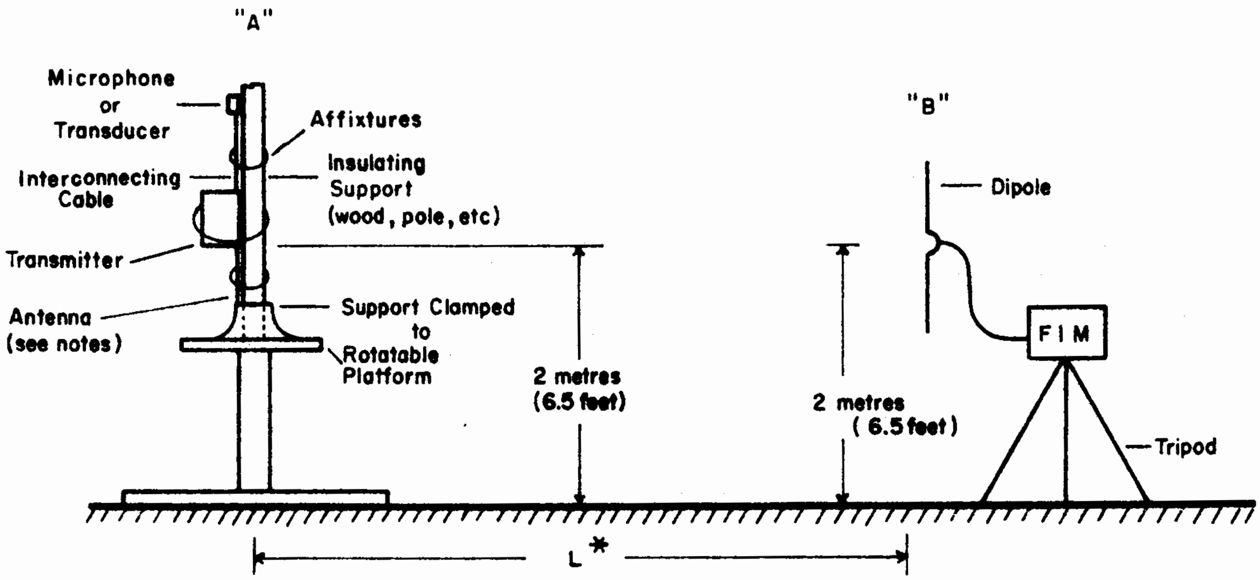
Issued under the authority of
the Minister of Communications

G C Brooks

G.C. Brooks,
Director,
Telecommunication
Engineering Branch



* Fig 1a L = 15 metres (50 feet)
Fig 1b L = 3 metres (10 feet)

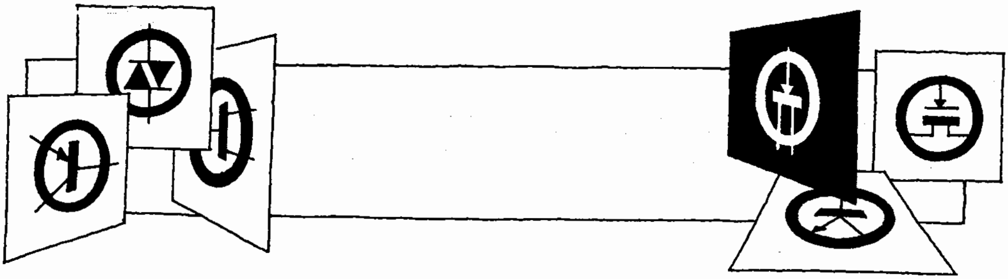
EQUIPMENT SET-UP FOR
FIELD STRENGTH MEASUREMENT

NOTES

(1) If antenna is rigid, it shall be oriented in a vertical position downwards.

(2) If antenna is flexible, it shall be affixed to the insulating support oriented vertically downwards.

(3) If antenna is a loop, it shall be vertical as in (2) but opened out in the form of a circle.



One Hundred Eighty-fourth in a Monthly Series by Lou Garner

LOWER semiconductor prices may be but one of the beneficial results of a new manufacturing process developed after three years of research by scientists and engineers of the Signetics Corporation (811 E. Arques Ave., Sunnyvale, CA 94086), a subsidiary of the Corning Glass Works. Dubbed "D-MOST," for Double-diffused Metal-Oxide Semiconductor Technology, the new production method is a relatively simple and inexpensive technique which can be used to fabricate discrete devices, such as individual diodes and transistors, as well as both linear and digital integrated circuits. It can be used effectively in turning out both small signal and high power units and is of particular value in the low-cost production of high performance VHF and UHF devices.

Currently, there are two popular techniques for producing semiconductor IC's—the bipolar and MOS (Metal-Oxide Semiconductor) methods. Within the MOS technology itself, there are several individual processes, including n-channel, p-channel, ion implantation, nitride, complementary, and silicon gate techniques. Bipolar circuits, in general, feature high operational speeds; but MOS circuits are more compact and require less power, although traditionally slower than bipolar.

Signetics' new D-MOST devices, on the other hand, have exhibited speeds five times faster than standard n-channel MOS units and at least ten times faster than devices made by the p-channel MOS process. D-MOST devices, in fact, are comparable in speed to fast bipolar transistors, but retain the advantages of high density, low power consumption, and low cost. Sample D-MOST digital devices exhibit a typical rise time of only 210 pico-seconds.

High frequency microwave devices can be produced using the new process as well as logic circuits and computer memory elements. Experimental D-MOST microwave transistors, for example, operate at frequen-

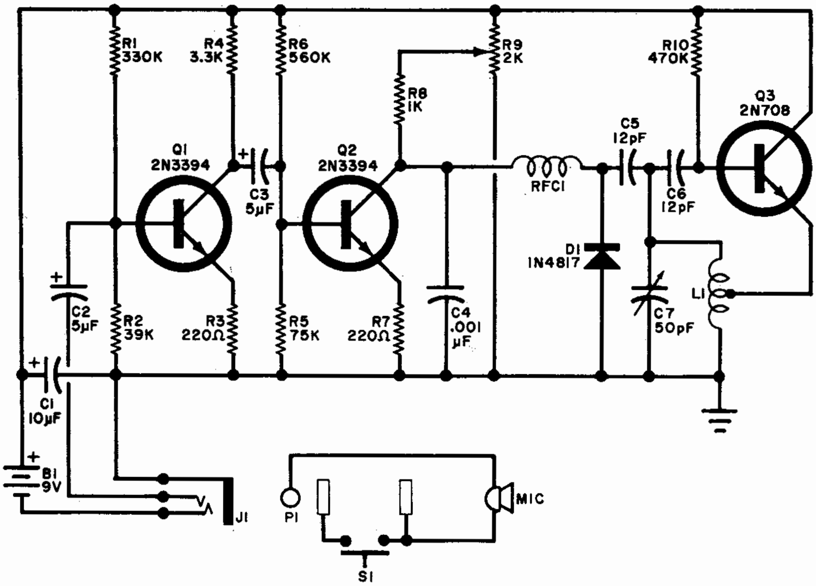
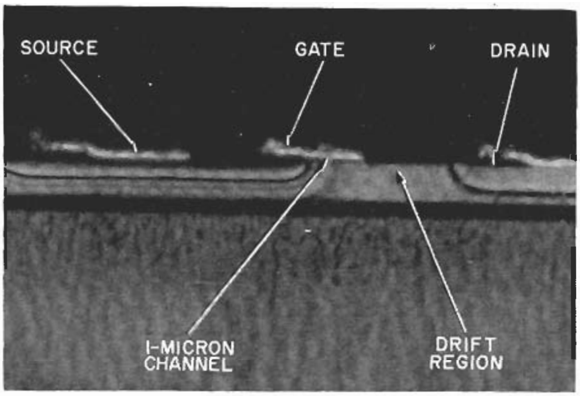


Fig. 1. This simple FM wireless microphone circuit uses the audio voltage to vary the junction capacitance of a conventional rectifier diode.

cies up to 10 GHz, with a typical noise figure of only 4.5 dB at 1.0 GHz, and a maximum gain of between 10 and 15 dB at that frequency. Even at 2 GHz, 7-dB gain is feasible. D-MOST transistors also outperform junction FET's, exhibiting very low feedback capacitance, low distortion, less cross modulation, lower parasitics, and greater linearity.

In practice, the speed of MOS-type digital circuits is determined by the length of the "channel" beneath the gate and situated between the source and drain electrodes. Transfer time is reduced and speed increased as channel length is shortened. In the conventional MOS process, however, this has the undesirable effect of lowering breakdown voltage, a problem which is eliminated with the D-MOST technique. Since breakdown voltage is not dependent on channel length with the new process, high voltage capability can be designed independently of channel length, thereby retaining high-frequency performance.



In D-MOST transistor, narrow control channel under gate increases speed of operation.

D-MOST transistors have been fabricated with channel widths of only 1 micron (millionth of a meter). Signetics has successfully assembled 1-GHz, 300-volt devices, and has also made other units with breakdown voltages as high as 600 volts, using two micron channels. The basic D-MOST process is essentially an optimum blend of bipolar and MOS techniques.

Useful Circuits. Featuring a novel modulation method, the FM wireless microphone circuit illustrated in Fig. 1 was submitted by reader Thomas Duncan (4240 N. E. 23rd Ave., Lighthouse Point, FL 33064). Instead of a conventional reactance stage, saturable inductor, or oscillator bias control, Tom has used a standard rectifier diode as his modulator, operating it as a varactor across the oscillator's tuned circuit. With the limited range required of unlicensed transmitters, the unit is intended for household use with standard FM broadcast band receivers.

Resistance-coupled amplifiers *Q1* and *Q2* serve as the audio preamp for the microphone. Base bias for *Q1* is established by voltage-divider *R1-R2* in conjunction with emitter resistor *R3*, with *R4* serving as the collector load. Similarly, *Q2*'s base bias is established by *R5-R6* and emitter resistor *R7*. Resistor *R8* and a portion of diode bias control *R9* serve as *Q2*'s collector load. Capacitors *C2* and *C3* provide audio coupling, *C5* and *C6* r-f coupling, *C1* power supply bypass, and *C4* r-f filtering. Transistor *Q3* serves as a modified Hartley oscillator, with its basic operating frequency established by tuned circuit *L1-C7*, and base bias supplied through *R10*. Circuit dc power is furnished by *B1*, controlled by spst push-to-talk switch *S1*.

In operation, a fixed dc bias is applied to diode *D1* through *R9*, *R8* and *RFC1*. The *instantaneous* bias changes, however, in accordance with the amplified audio signal delivered by *Q2*, causing corresponding changes in its effective anode-cathode capacitance. Since *D1* is essentially in parallel with *L1-C7*, the tuned circuit's frequency changes accordingly, generating an FM r-f signal.

Except for hand-wound coil *L1*, standard components are used in the instrument. The coil consists of 4 turns of #18 wire, ¼" in diameter and 1" long, with a tap on the second turn from ground.

Tom writes that the design is well-suited to pref board or etched circuit construction, and that neither layout nor lead dress is overly critical, except in the oscillator/varactor circuit, where good VHF wiring practice should be observed. After assembly and check-out, trimmer *C7* should be adjusted so that the instrument's signal is picked up at a "dead" spot (where there is no local station) on the dial of a nearby FM receiver. Afterwards, *R9* should be adjusted for optimum modulation and best clarity, with *C7* retuned as necessary.

Another interesting circuit is illustrated in Fig. 2—a touch control switch which can be used to operate lights, bells, buzzers, fans, household appliances, small motors, or any similar electrical devices. The circuit was abstracted from the instruction folder furnished with Motorola's HEP Field Effect Transistor Experimenter Kit Model HEK-2. An inexpensive kit consisting of a pair of

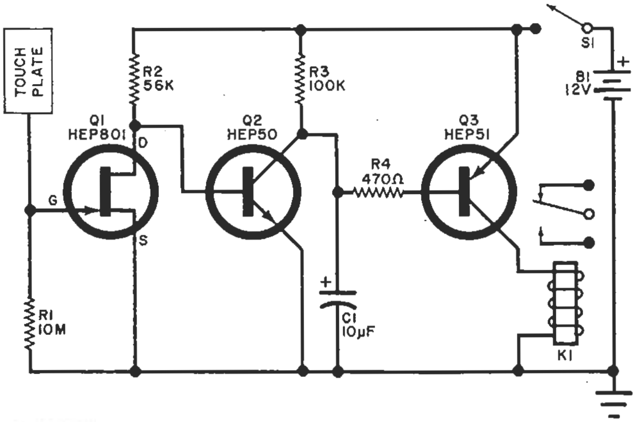


Fig. 2. Simple touch switch can be used to operate almost any type of alarm or low-power appliance. It can be built from the readily available Motorola HEK2, FET Experimenter's Kit.

can be recycled for use in the manufacture of other semiconductor devices.

A secondary advantage of the new rectangular format is a reduction in losses due to accidental damage. If a 2″ × 6″ wafer breaks or cracks, any parts remaining that are at least two inches square can be processed normally. This contrasts with round wafers, in which a split or crack in the edge complicates masking and generally requires that the whole wafer be discarded.

The new wafers are being used initially in epitaxial-base silicon power transistors, including Motorola's extensive line of complementary transistors for outputs of up to 100 watts. Among the transistors being produced this way are those in plastic *Thermopad* packages, which contain dice as large as 0.200″ square, and some metal-cased types utilizing dice as large as 0.275″ square.

In the future, it is likely that other lines of semiconductor devices will use the large rectangular wafers. Integrated circuits, and particularly LSI units, are well suited to this type of improved production technique.

Reader's Circuit. "I enclose an AM transmitter circuit which I designed and built for a wireless phonograph. You probably receive a lot of phone oscillator circuits, but this one is different." Thus started a recent letter from reader Gary McClellan of La Habra, Calif. Gary is right—his circuit, shown in Fig. 3, *is different*. The overwhelming majority of "home broadcaster" circuits use modulated oscillators, with one or more stages of audio amplification, and almost all of them have performance limitations, since a modulated oscillator is not overly stable. Frequency modulation as well as amplitude modulation may be present, and the circuit's basic frequency may shift with higher modulation levels or changes in antenna loading. Gary's circuit, on the other hand, has a modulated buffer amplifier between the r.f. oscillator and the antenna, thus insuring greater overall stability. His basic concept is similar to that used in the design of commercial transmitters.

Referring to the schematic diagram, *Q1* serves as a modified Hartley oscillator, with its basic operating frequency determined by tuned circuit *L1-C1*. The r.f. signal is coupled to the buffer amplifier (*Q2*) by interstage capacitor *C2*. A common collector load, *R1*, is used for both the buffer and modulator (*Q3*) stages, with the modulated r.f. signal appearing across this load coupled to the antenna through isolation capacitor *C3*. Audio input is via coupling capacitor *C4*.

Gary has used inexpensive, readily available components in his design. All resistors are half-watt types. *C5* is a 15-volt electrolytic, and *C4* may be either a low-voltage ceramic disc or a tubular paper capacitor. Inductor *L1* is a standard tapped broadcast-band oscillator coil, while a single battery or series-connected penlight or flashlight cells furnishing from 9 to 12 volts may be used for the power supply, *B1*.

Although good wiring practice should be observed, with all r.f. signal-carrying leads kept short and direct, the circuit's overall layout and lead dress are not especially critical. The unit can be assembled on an etched circuit or perf board or even on a conventional metal chassis, as preferred. Breadboard assembly may be used for demonstration of Science Fair applications.

In operation, the audio signal source is connected to the input terminals through a shielded cable. Adequate drive may be obtained from a high-output crystal or ceramic cartridge or from a conventional

(*Continued on page* 94)

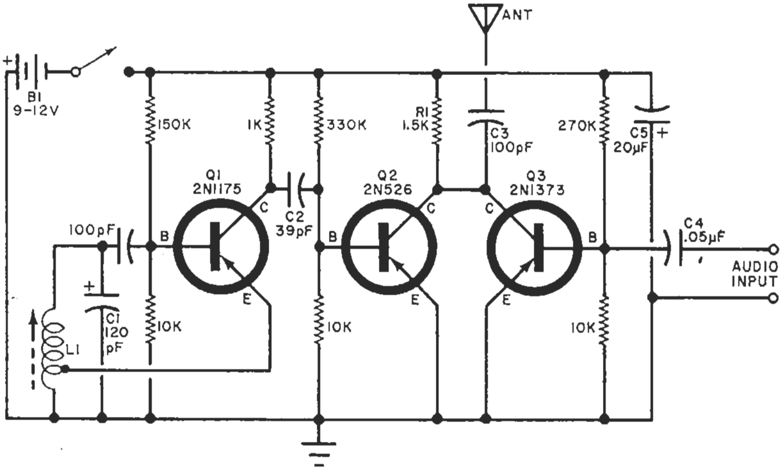
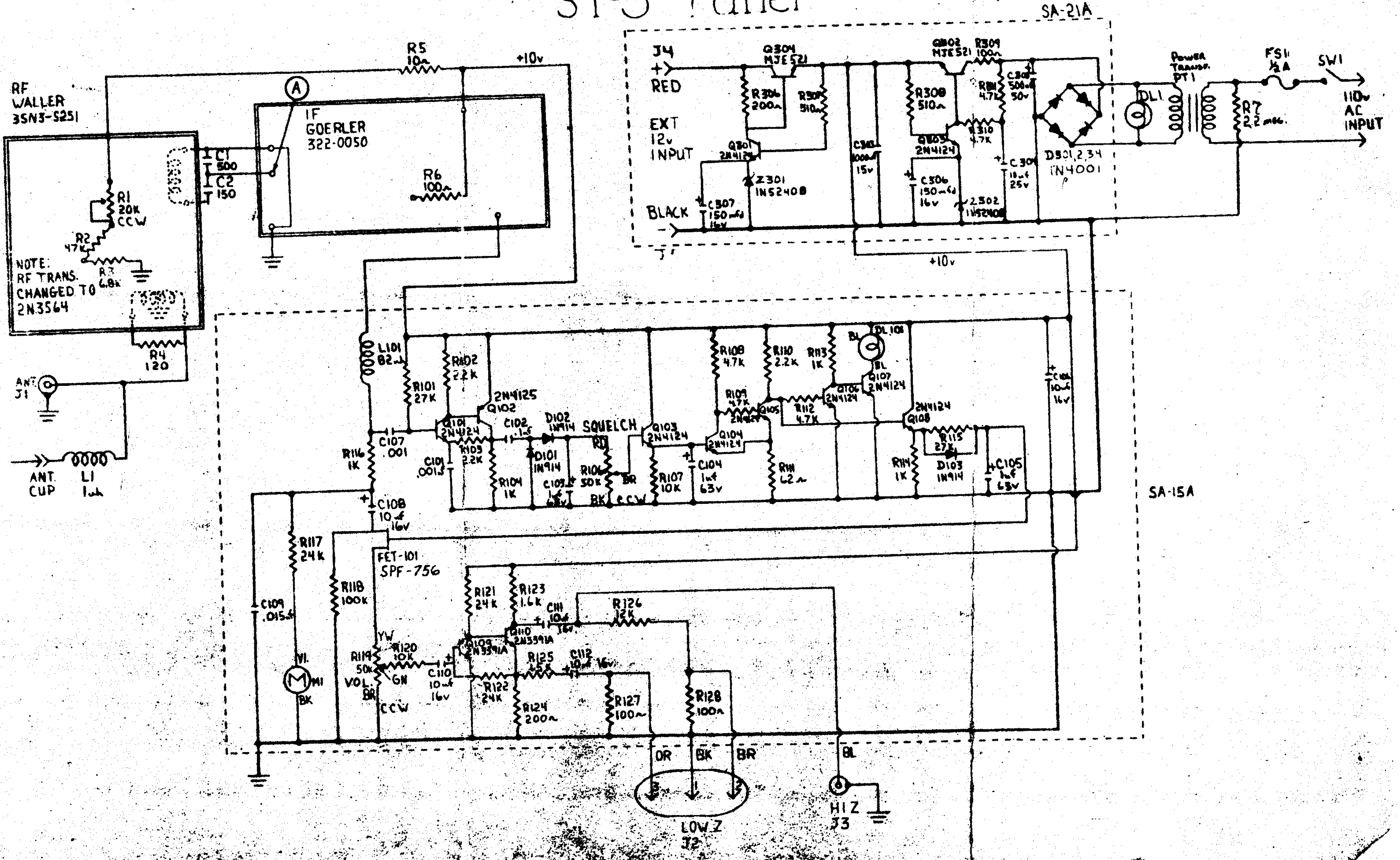


Fig. 3. Unusual AM transmitter circuit has modulated buffer amplifier to improve overall stability of audio system.

Edcor Wireless Mike Receiver

DR.	
TITLE ST-3	ENG.
NO.	DATE 2-20-73	APP.

ST-3 Tuner



FM Wireless Microphone

Fig. 1. Miniature transistorized FM transmitter shown in use.

By

D. E. THOMAS and J. M. KLEIN

Bell Telephone Laboratories

An experimental FM transmitter that can be easily built from readily available components at a cost of approximately $20.00.

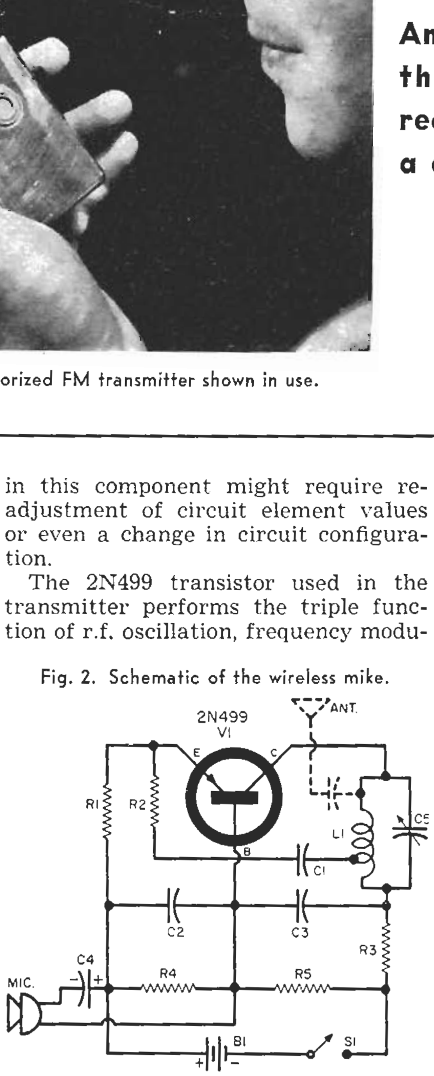
EVER since the appearance of the article describing an experimental transistorized FM transmitter[1] numerous requests have been received for information on commercial components for duplicating the original circuit. Unfortunately, the point-contact transistor around which the original transmitter was designed was an experimental device which became obsolete before it could be coded for manufacture.

Since requests for information on how to build a similar transmitter are still being received, the authors worked out another circuit covering an experimental FM transmitter which can be built with readily available commercial components at a cost of approximately $20.00. Construction is simple and no difficulties should be encountered.

A photograph of the new transmitter, which was designed as a wireless microphone, is shown in Fig. 1. Like the earlier circuit, it was designed to operate in the commercial FM band. The schematic diagram is shown in Fig. 2, along with a listing of the required parts. Detailed specifications are given because of repeated requests for complete construction details. However, equivalent components of other types will work equally well and, in the interests of ready availability and possible cost saving, many experimenters may be willing to sacrifice size and substitute somewhat larger components than those specified. One possible exception to the "substitution" rule would be the transistor since a change in this component might require readjustment of circuit element values or even a change in circuit configuration.

The 2N499 transistor used in the transmitter performs the triple function of r.f. oscillation, frequency modulation, and audio amplification. Since the frequency of oscillation of this transistor is somewhat closer to its cut-off frequency than the point-contact transistor used in the original transmitter, less phase shift is required in the feedback coupling circuit to maintain oscillation. Feedback is obtained from a tap on the tank coil, L_1, through a series resistor-capacitor (R_2 and C_1), rather than through a capacitance only. The frequency modulation function of the transmitter is accomplished in the same way as described for the earlier transmitter—namely by feedback-loop phase shift, resulting from *alpha* cut-off frequency shift under the control of an audio-frequency signal input.

Fig. 2. Schematic of the wireless mike.



R_1—300-400 ohm, 1/10 w. res.
R_2—240 ohm, 1/10 w. res.
R_3—1500 ohm, 1/10 w. res.
R_4—2400 ohm, 1/10 w. res.
R_5—12,000 ohm, 1/10 w. res.
All resistors are Allen Bradley Type TR
C_1—15 μμf. mica capacitor
C_2, C_3—.001 μf. disc ceramic capacitor
C_4—20 μf., 15 v. elec. capacitor
C_5—.8-12 μμf. piston-type variable trimmer
L_1—6 t. #24 bare tinned copper wire on 1/4" 36 TPI polystyrene coil form. Feedback tap at exactly 1 full turn.
Mic.—Reluctance microphone (Shure MC-20)
Ant.—Telescoping antenna (Lafayette F-343 with sections cut down to approx. 2 3/4", see text)
B_1—15-volt battery (Burgess Y-10 or Eveready 504)
S_1—S.p.s.t. slide switch
V_1—Transistor (Philco 2N499)
1—Can (Type HU315-2) and cover (Type HU-315C-2) available from Hudson Tool & Die Co., Inc., Newark 5, N. J.

Since the 2N499 is a junction-type transistor, its high common-emitter current gain at audio frequencies was used to eliminate the need for an additional transistor to amplify the audio output of the microphone to the level needed to produce adequate frequency deviation. This is accomplished by introducing the audio signal into the base of the transistor. Fig. 3 is the equivalent circuit of the transmitter at d.c. and audio frequencies. It will be noted that R_1 appears directly in series with the emitter of the transistor at audio frequencies. This reduces the maximum available common-emitter current gain. If more audio gain is needed, it can be obtained by shunting R_1 by means of the optional *LRC* circuit shown in Fig. 3. The inductance L_2, which can be any low-capacitance r.f. choke with an inductance greater than 1 μhy., is needed to avoid shunting the emitter at r.f. and interfering

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[1] "Single-Transistor F-M Transmitter," Electronics, February 1954. Pages 130-133.

with r.f. oscillation. The capacitance, C_6, which should be of the same value and type as C_4, is needed to avoid disturbing the d.c. biasing of the transis~~tor. The~~ audio gain can then be adjusted by varying the resistance of R_6.

Construction

The actual placement of the components may play an important part in circuit performance at v.h.f. frequencies. The layout indicated by the callouts of Fig. 4 should be followed as closely as possible. The transmitter shown in this photograph has a miniature jack for connecting an external microphone and matching transformer. This jack can be seen between the microphone and switch in the picture.

All components, except the antenna, are mounted on one side of a 2½" x 1⅞" panel. Most of the parts are supported by their own leads which are passed through holes in the panel and wired on the underside. Fig. 5 shows this component wiring and the antenna mount. The bottom section of the antenna is wound in polyethylene sheet and clamped to the underside of the panel directly beneath the L_1-C_5 tank circuit so that its only r.f. coupling is the parasitic capacitance between it and the tank circuit. This limits radiation to that needed for a portable p.a. microphone with a range of about 200 feet and also reduces frequency pulling due to any change in radiation impedance of the antenna.

Adjustments

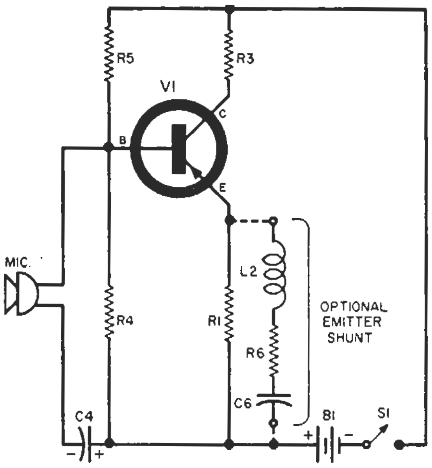


Fig. 3. Equivalent circuit. Value of R_6 is found by experimenting with 10,000-ohm pot.

The value of R_1 should be adjusted for the particular transistor used so that the d.c. voltage drop across R_3 is approximately 6 volts when the battery is new. It has been our experience that the R_1 adjustment, plus the adjustment of C_5 to give the desired carrier frequency, will be all that is required. However, for those 2N499 transistors which happen to be on the edge of production acceptability, the circuit may not oscillate. In this case, a slight adjustment of R_2 and/or C_1 should produce oscillation.

Possible Variations

An external microphone of different impedance or larger size may be used. The space occupied by the small reluctance microphone could then be utilized for a suitable audio impedance-matching transformer. The alternate microphone selected should be connected to the transmitter by a coaxial microphone cable. In this case, the microphone cable will provide sufficient radiation for limited local transmissions and the collapsible dipole antenna may be omitted. The audio input impedance of the transmitter will vary widely depending on the transistor used, the value of R_1, and whether an emitter shunt is used to increase the audio gain, as shown in Fig. 3 and described previously. However, if an audio impedance of 1000 ohms is assumed and an audio transformer selected to match the microphone to 1000 ohms, the actual audio impedance match will be satisfactory.

Considerably greater than public-address range could be obtained by use of an efficient radiator suitably coupled to the transmitter. However, it must be remembered that the wireless microphone described is an experimental device. Any wireless microphone built for actual p.a. or entertainment use would have to comply with FCC regulations with respect to transmitter frequency, frequency stability, and power.

Acknowledgement

The concept of a frequency modulated transistorized transmitter originated with R. L. Wallace, Jr. The earliest transmitter was built by L. C. Schimpf, using an early tetrode transistor modulated by a condenser microphone across the tank circuit. —30—

Fig. 4. The layout of compo... employed in the transmitter.

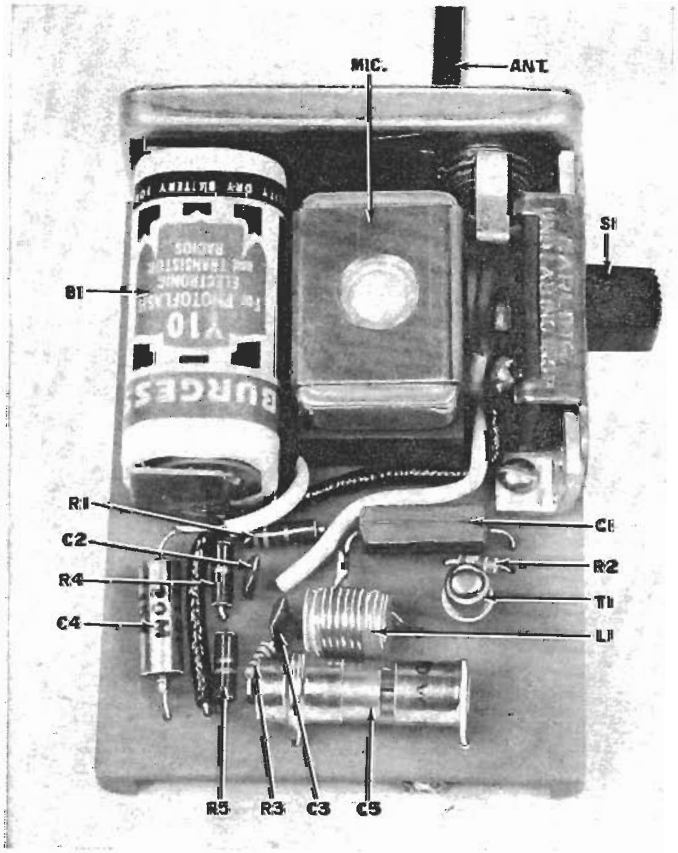
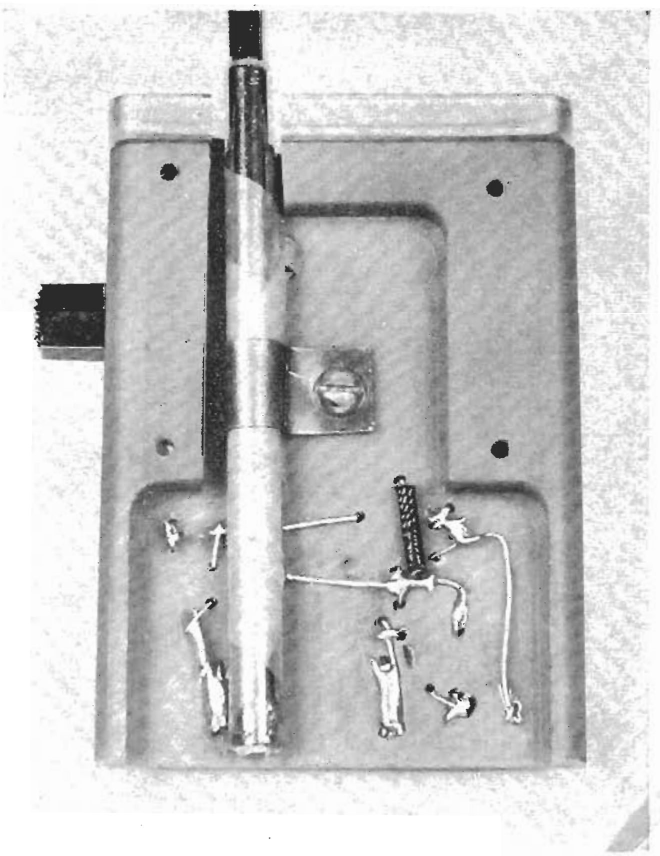
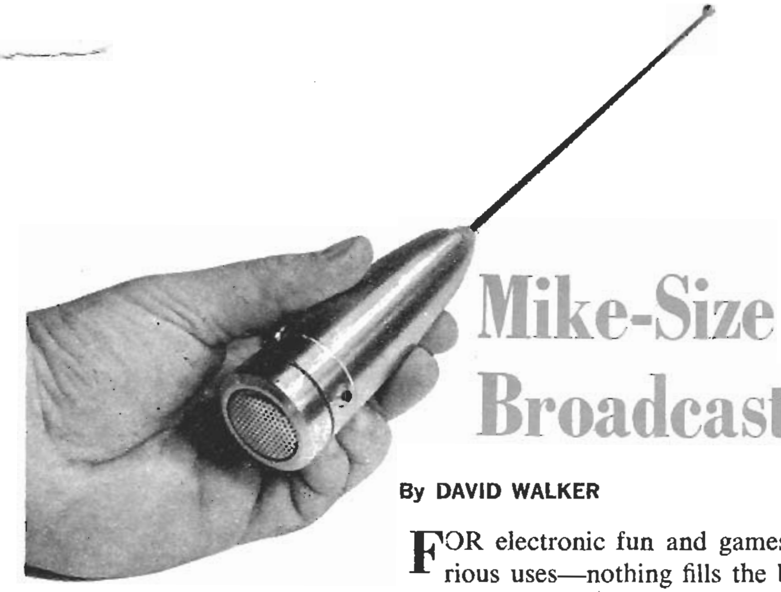


Fig. 5. Backside view of unit shows wiring and antenna mount.





Mike-Size Broadcast Station

By DAVID WALKER

FOR electronic fun and games—and even some serious uses—nothing fills the bill like a wireless microphone. Only thing is, that word wireless is somewhat misleading because the usual set up involves a mike with a wire going to its transmitter, and an antenna. You call this wireless? We don't.

Here's a wireless mike that really does live up to its name. Our Mike-Size Broadcast Station is a complete three-transistor broadcast-band transmitter built inside a mike case. Instead of a cord hanging out the back of the mike, there's a telescoping whip antenna. Frequency is adjustable from about 700 to 900 kc and range is about 20 ft.

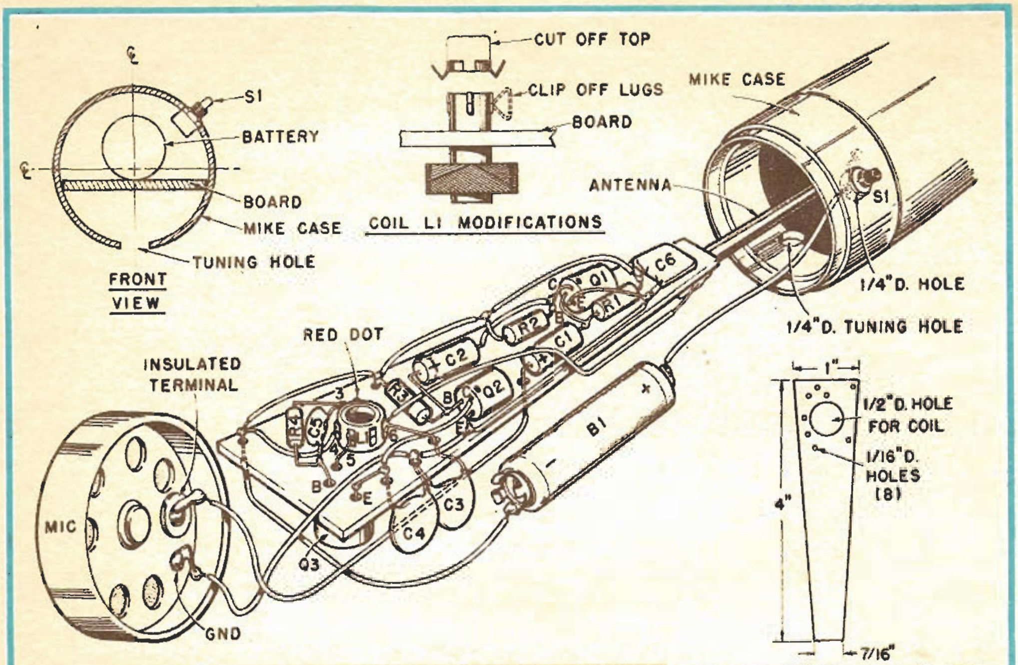
Construction. Most assembly is shown in the pictorial, so lets look at not-so-obvious details. Open the mike. Cut the circuit board to fit into the case, then drill the holes for the coil and parts leads. Mount the coil, battery and whip antenna by cementing in place with epoxy. But before you cement in the coil, cut off the top part—the end with the mounting clip—and clip off the metal *loop* at each lug. The coil can now be cemented into its hole.

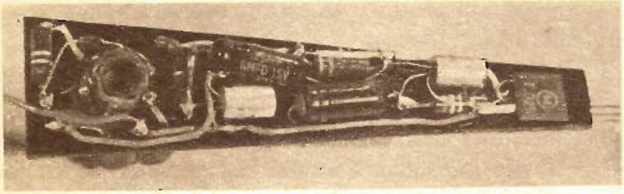
Before installing the antenna unscrew its tip then slide the bottom section off. Next, solder a length of hookup wire to the bottom of the whip. The antenna may now be cemented to the board. The grommet through which the mike's wire passed is used to insulate the whip from the case. Cement or tape the battery on the board.

Watch the lead placement to prevent shorts and use spaghetti on wires that cross. Be sure there are no bare wires or parts at the edges of the board that might touch the mike case. To be doubly sure, line the inside of the case with heavy paper.

Drill two ¼-in.-dia. holes in the case where shown in the pictorial. Push-button switch S1 is mounted in one by simply force-fitting it in place. If it's loose, install the mounting nut outside the case. Now bend one switch lug against the case and solder it there. To the other lug solder a 5-in. length of No. 26 enameled wire. The other end of the wire will be soldered to the positive battery terminal. Drill the other hole in the case so it will be right over L1's slug.

Initial Test. Before attempting to slide the board inside the case,





As our mike's case is narrower at rear, board is tapered. Before cutting board for your mike, determine size with a piece of cardboard. Sketch at top shows modification to be made to L1 to reduce its size. Cross-section sketch at upper left shows approximate location of board, battery and holes for push-button switch and tuning slug on coil L1.

Broadcast Station

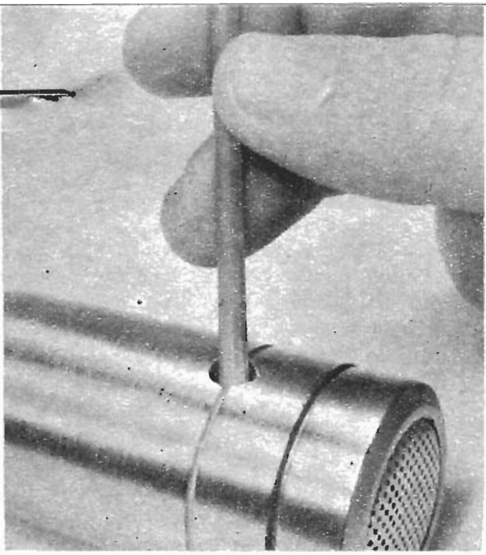
make a quick electrical check. Place a radio nearby and tune it to a clear spot on the dial around 800 kc. Connect a temporary jumper wire between the two metal parts of the mike case (that is; from the mike element to the main barrel). Remember that when the case is open it's possible for the whip antenna to touch the case and this will damage the battery.

Push S1 and check if there's a signal in the radio. Tune the radio dial as you talk in the mike to find the signal and adjust L1's slug with a plastic alignment tool. If you want to shift to a different spot on the broadcast band, use a different capacitor for C3; more capacitance (about 400 $\mu\mu$f) lowers the frequency, a smaller capacitor raises it.

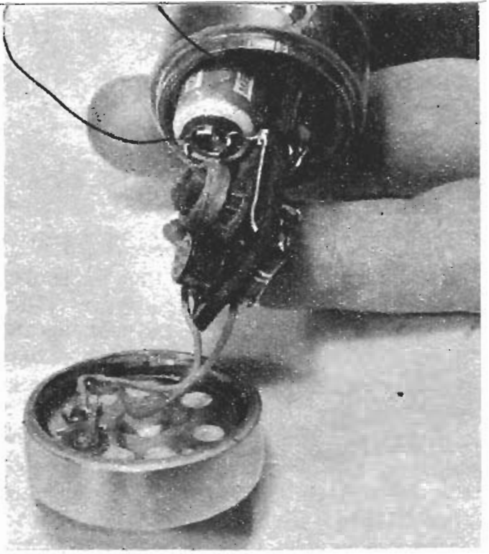
Sliding the Unit Together. Hold the case and look into the opening. As shown in the upper left of the pictorial, switch S1 should

PARTS LIST

B1—9.8-V mercury battery (Mallory TR177 or equiv.)
C1,C2—6 μf, 15 V electrolytic capacitor
C3—360 $\mu\mu$f, 15 V or higher disc capacitor
C4—.01 μf, 15 V or higher disc capacitor
C5—.001 μf, 15 V or higher disc capacitor
C6—.02 μf, 15 V or higher disc caapcitor
L1—Miniature oscillator coil (J. W. Miller 2023, Lafayette 34 E 87022
Mic.—Tubular crystal microphone (Lafayette 99 E 45874
Q1—2N408 transistor (RCA)
Q2—2N2613 transistor (RCA)
Q3—GE-1 transistor (GE)
R1—270,000 ohm, 1/4 watt, 10% resistor
R2,R4—3,300 ohm, 1/4 watt, 10% resistor
R3—1 megohm, 1/4 watt, 10% resistor
S1—SPST normally-open miniature push-button switch (Grayhill 39-1, Allied 56 A 4968)
Misc.—52-in. telescoping whip antenna (Lafayette 99 E 30082), No. 26 enameled wire, perforated circuit board



Plastic alignment tool fits through ¼-in. dia. hole in side of case; it adjusts slug of coil L1. Final tune up should be made with board in case.



Board being fitted in case; The wire loop is No. 26 enameled wire which goes from positive contact on battery to push-button switch in case.

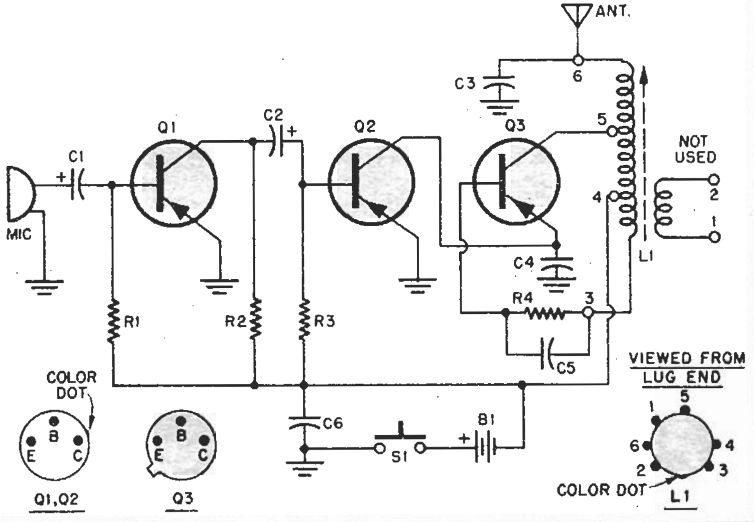
be at the upper right; the tuning hole is down. Insert the board into the case keeping the battery on top. As you do this carefully position the wire from the switch to the battery so the board slides in easily.

Don't Press the Button. Place one probe of an ohmmeter on the metal case and the other on the antenna. You should read several thousand ohms one way and a few hundred-thousand ohms after reversing the probes. Put the positive probe on the case and the negative on the antenna. Press the button and the meter should indicate the battery voltage.

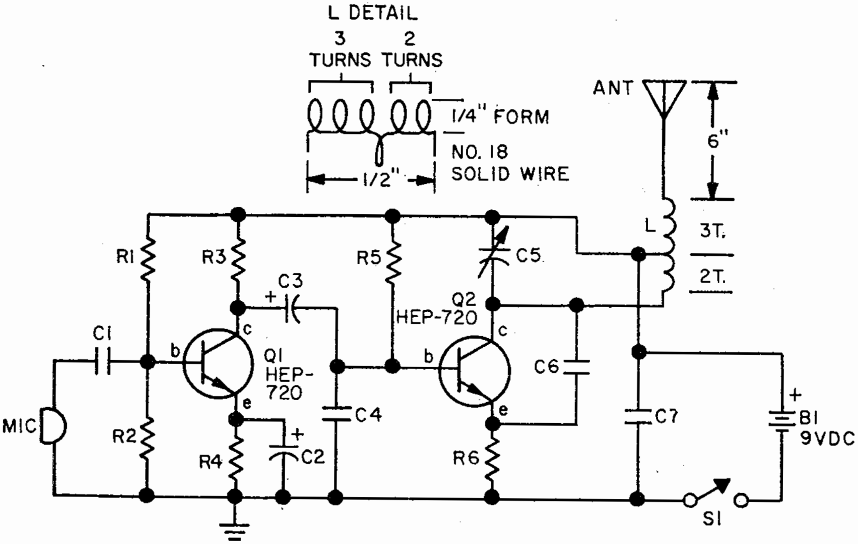
Operation. Several factors affect range and performance. Turn on the radio, tune to a clear spot near 800 kc and turn volume to the usual listening level. Grip the mike, but be careful not to touch the antenna. Press the button and talk. You'll have to adjust coil L1 *while you speak.* Insert a plastic alignment tool in the tuning hole. Talk into the mike and turn L1's slug for the clearest sound from the radio.

You'll get the best range by trying the whip in various positions while talking, or you can turn the radio. Greater range can be achieved by adding an antenna to the radio.

Schematic. Transistor Q1 amplifies signal from mike and feeds it to driver Q2. Signal from Q2 modulates oscillator Q3. Ground connection at left side of switch S1 is made to case. Circuit ground is made to case via ground lug on mike (see pictorial), therefore mike element must touch case so unit will operate.



99 FM Wireless Mike



PARTS LIST FOR FM WIRELESS MIKE

B1—9-V battery, Type 2U6
C1—0.05-uF, 3-VDC capacitor
C2—20-uF, 3-VDC electrolytic capacitor
C3—5-uF, 12-VDC electrolytic capacitor
C4—47-pF, 25-VDC capacitor
C5—5-30 pF trimmer capacitor
C6—6.8-pF ceramic capacitor
C7—0.01-uF, 10-VDC capacitor
L1—See pictorial detail
MIC—Crystal or ceramic microphone element
Q1, Q2—npn transistor HEP—720
R1—47,000-ohm, ½-watt resistor
R2—33,000-ohm, ½-watt resistor
R3—1500-ohm, ½-watt resistor
R4—3300-ohm, ½-watt resistor
R5—100,000-ohm, ½-watt resistor
R6—470-ohm, ½-watt resistor
S1—Spst switch

Just speak or play into the microphone and you'll broadcast to an FM receiver at distances up to 50 feet (maybe 100 feet if the wind is right). Use standard RF wiring precautions and make coil L1 exactly as shown. Best speech clarity is obtained by using a crystal or ceramic mike. For music reproduction, substitute a dynamic mike element.

The unit can be assembled on a perfboard using push-in terminals for tie points. The case must be metal to prevent hand capacitance from continuously changing the output frequency. Pass the 6-in. solid wire antenna through the metal case using a ¼-in. hole and a matching rubber grommet for an insulator.