Electronics World

APRIL, 1962

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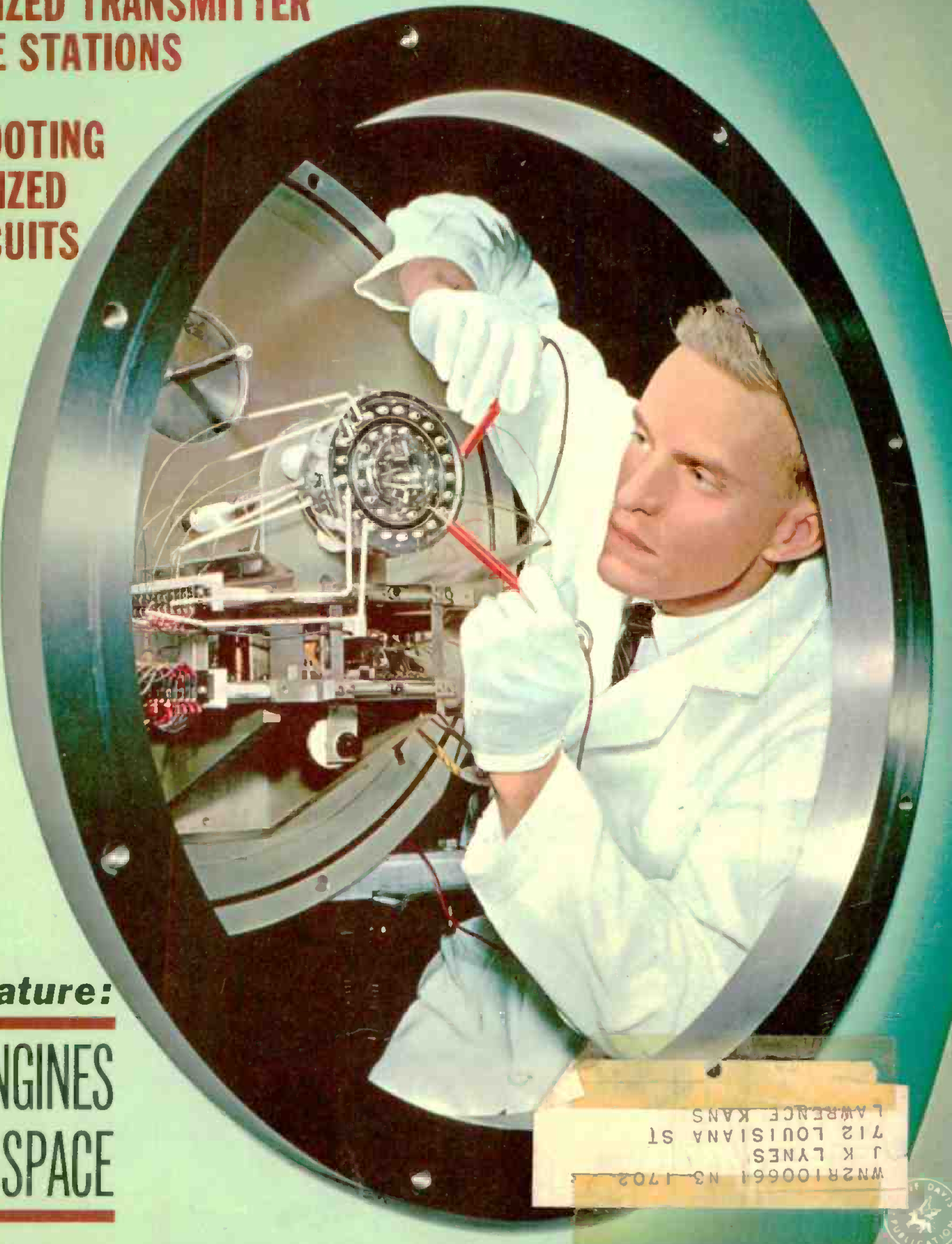

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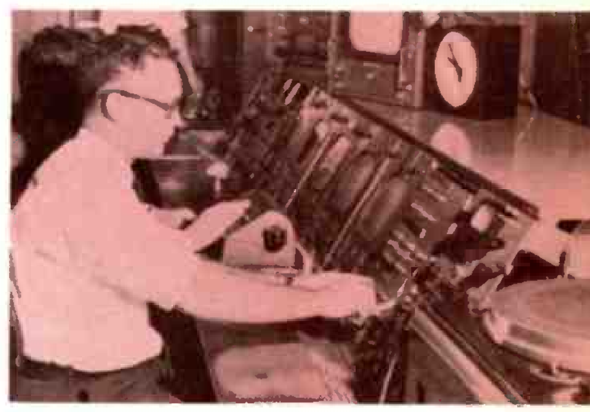

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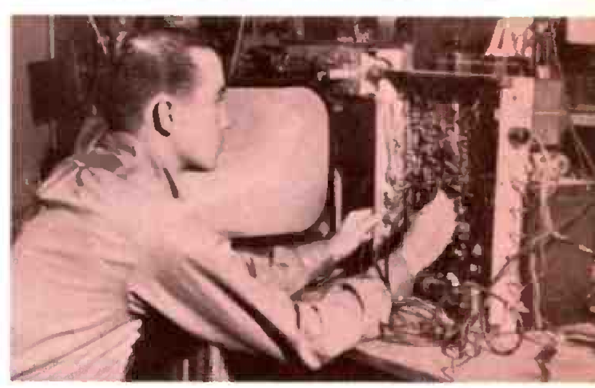

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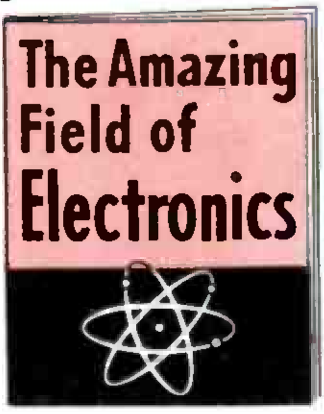

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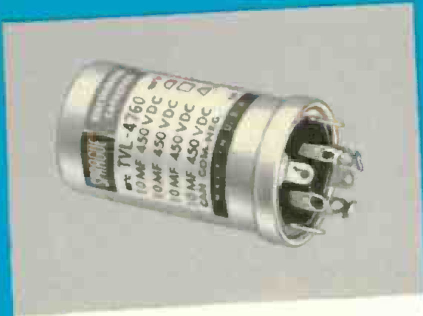

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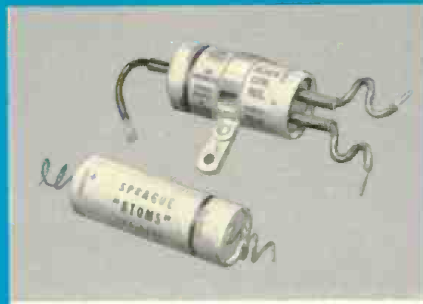

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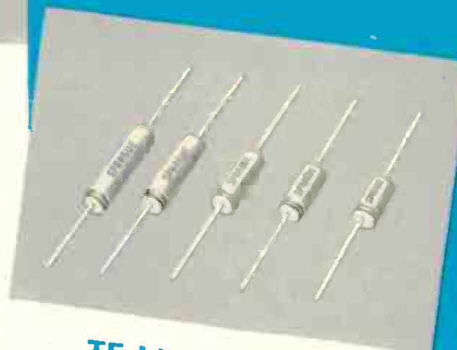

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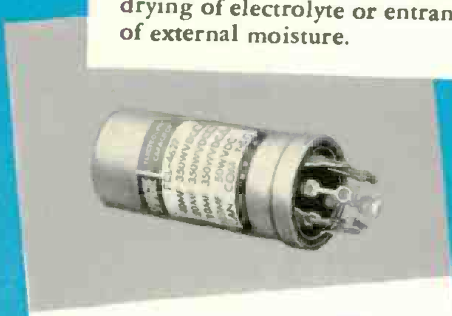

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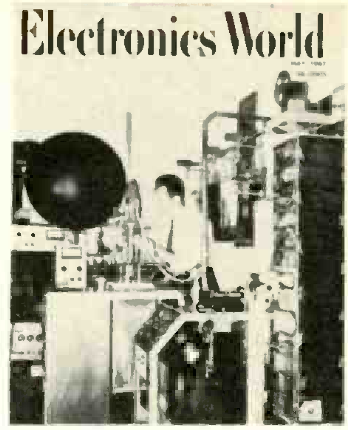

COMING NEXT MONTH

NOISE & ITS MEASUREMENT
Man, the noisemaker, spends millions each year to reduce noise. In order to check the effectiveness of his remedies, instruments must be used to measure noise levels. Here is how the instruments do the job.

DIRECT HEAT-TO-ELECTRICITY ENERGY CONVERSION
Much work has been done on direct heat-to-electricity conversion systems for use in military and industrial laboratories and space vehicles. The article surveys some of these systems that produce electricity directly from heat without the use of moving parts or chemical batteries.

DESIGN OF TRANSISTOR HI-FI AMPLIFIERS
Solid-state amplifiers with performance that equals the best of their vacuum-tube counterparts are just around the corner. Article suggests circuits for 7½ to 12 watt amplifiers using new diffused silicon transistors.

MULTI-WATT TRANSISTORIZED CB TRANSCEIVERS
Design and construction of fully transistorized CB equipment which delivers several watts of r.f. output and operates close to the maximum legal power limit.

TRANSISTORIZED PHOTORHYTHMICON—DANCING LIGHTS
Construction of a simple semiconductor color organ whose colored-light display varies in hue and intensity to follow musical signals.

MISMATCHING HI-FI AMPLIFIERS
What happens to distortion and frequency response when your power amplifier is mismatched? Here are some results of deliberate mismatching as measured on a typical medium-power hi-fi amplifier.

1962 TUBE INVENTORY FOR SERVICE SHOPS
Annual, up-to-date list of tubes that should be stocked by the service shop, together with an estimate of the relative quantity of each type that should be on hand. A separate set of recommended quantities is listed for the outside-call caddy.

All these and many more interesting and informative articles will be yours in the May issue of ELECTRONICS WORLD . . . on sale April 24th

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...for the Record

By **W. A. STOCKLIN**
Editor

WILL 50 MILLION TV SETS BECOME OBSOLETE?

NO ONE really knows if most of the TV sets now in use will become obsolete but there is that possibility. At least to the degree that a u.h.f. converter or a u.h.f. tuner strip and a new antenna system will be required if all our TV stations move into the u.h.f. band. It happened to FM back in 1945 when the FCC changed transmission frequency from 42-50 mc. to the present 88-108 mc. There is no doubt in our mind that a similar change is going to occur with television. As to when this will occur, is anyone's guess. The final decision will have to be made by the FCC. There are rumors that it may take up to ten years for complete conversion to u.h.f. by the broadcasters, but it is rather difficult for us to conceive that the FCC would wait this long. We believe that the FCC will start making regulation changes as soon as it is technically possible and that those areas that have limited TV service at the present time will be the first to make the change to all-u.h.f. operation.

The television industry and the FCC are fully aware of the fact that the present 12 v.h.f. channels are insufficient to give proper television coverage across the nation, and there appears to be only one solution. Changing the present TV frequencies to the u.h.f. band will provide 70 separate channels. When the present frequencies were assigned, the electronic industry had very little knowledge of u.h.f. transmission characteristics and could not conceive of a television application for this band. Much has been learned over the past years and the present state of the art is such that u.h.f. television presents no problems that have not been solved. In some areas u.h.f. may even provide better performance than v.h.f. The television industry did try to expand some years ago by permitting both v.h.f. and u.h.f. stations to operate, sometimes separately, and in many cases, intermixed in the same area. Intermixing, as it turned out, proved to be disastrous financially to many u.h.f. stations. Viewers, wherever they had a choice between the two, usually chose the less-expensive v.h.f. receivers.

The FCC, directed by Chairman Newton N. Minow, is fully cognizant of the problem involved and of the Commission's responsibility, not only to the TV broadcasters, but particularly, to the viewer. With this thought in mind, Chairman Minow is asking Congress to pass a law to be effective as soon as possible to require all TV set manufacturers to include both v.h.f. and u.h.f. tuners in all new TV sets. In time, as users replace their present sets with the new, all-channel receivers, this will provide a growing viewing audience for u.h.f. stations. If this law is passed by Congress, and we feel sure that it must be, television sets should increase in cost by some $20.00 to $40.00.

At the present time *Jerrold Electronics Corporation,* under an FCC contract, is making an extensive field test of u.h.f. reception in the New York City area. Since July, 1961, TV station WUHF (channel 31) has been transmitting programs for the sole purpose of making these field tests. A total of 5000 u.h.f. receiving installations and measurements are being made and the contract is scheduled for completion on July 15 of this year. An interesting factor is that the choice of individual test locations was not left up to the judgment of the technicians involved, but all 5000 individual sites were chosen by the Census Bureau and no substitutions are permitted. Analysts conclude that at least 90 per-cent of the total of 5000 sites must be tested or else the results are considered to be invalid. All present indications are that the 90 per-cent quota will be met.

Obviously, final results of the test have not been evaluated, but expectations are that u.h.f. performance will not involve any technical difficulties beyond those normally encountered in v.h.f. transmission. In fact, it has been noted already that u.h.f. signal penetration through buildings is much better than v.h.f. There seems to be no difference in picture quality and signal strength. Problems involving "ghosts" seem to be the same. Such u.h.f. transmissions have a much more line-of-sight characteristic and signals therefore have much less tendency to bend with the curvature of the earth. This does mean that far fringe reception will not be as good as v.h.f., but this is more of an advantage than a disadvantage. On the other hand, v.h.f. has more of a tendency to skip and, as a result, co-channel interference is a serious problem in some areas.

Since there are 70 channels in the u.h.f. band, it is conceivable that stations will be permitted to use more than one channel to cover a given area. This is not costly and has the tremendous advantage in that dead areas, which also plague the industry today, will be blanketed.

Television must go u.h.f. With such a change, TV will be made available to more areas and will be able to reach more people—with no more technical difficulties than we have today. ▲

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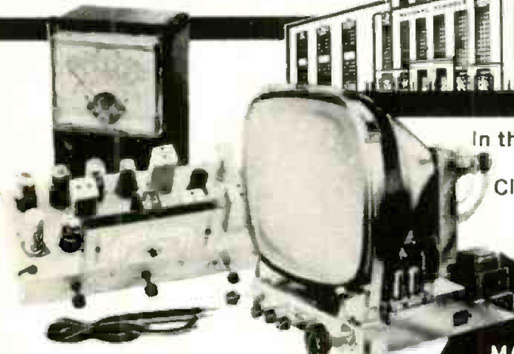

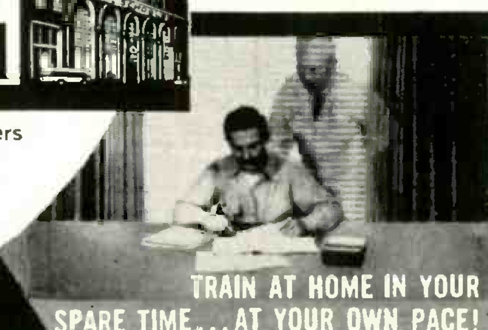

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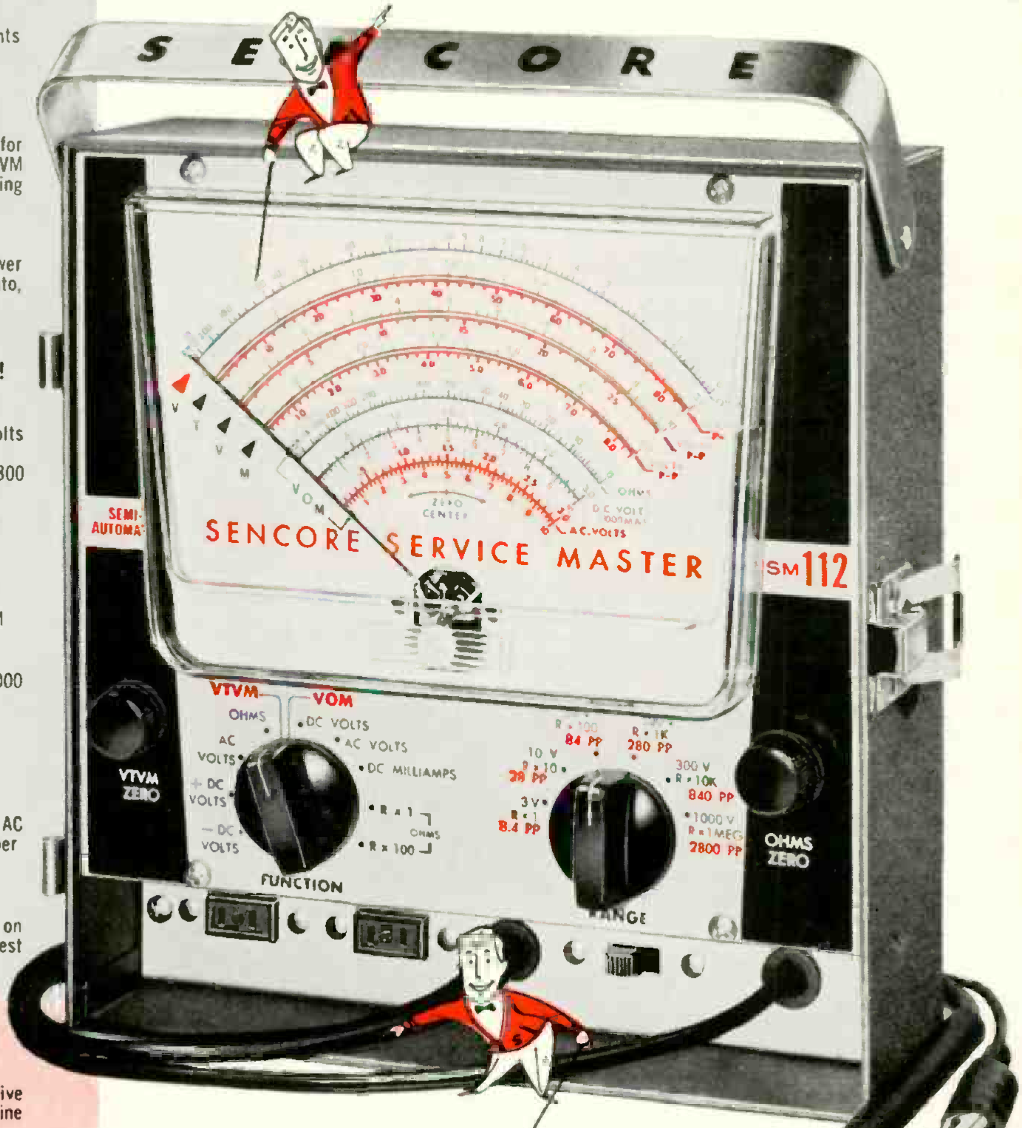

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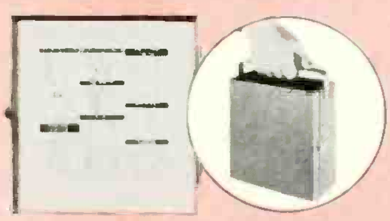

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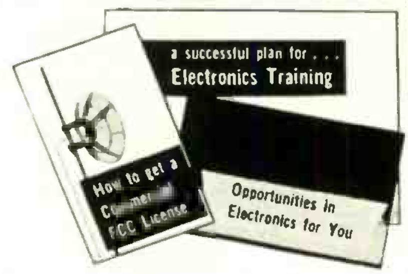

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LETTERS FROM OUR READERS

MUSIC POWER

To the Editors:

Since so many manufacturers of hi-fi equipment use the music-power rating, why do you persist in using steady-state. sine-wave measurements in your lab reports?

RICHARD A. SCOTT
Westfield, New Jersey

We are aware that many manufacturers in our industry use music-power ratings and we have stated our own feelings on this subject many times in the past. See the editorials "The New Music-Power Rating" (June 1960 issue), and "Hirsch-Houck Lab Reports" (February 1961 issue). Briefly, we find nothing wrong with a manufacturer's use of music-power rating providing he clearly states that this is the power rating quoted in his specs. But we also suggested that it would be a good idea to provide the continuous sine-wave power rating as well, as an additional specification. Further, we believe that the continuous sine-wave power rating is a fair way of comparing one amplifier with another for two reasons: (1) it is the more severe test that represents how the amplifier will perform under very stringent conditions, and (2) it is readily duplicated by our readers, most of whom are technically oriented.

We realize that there is much to be said on the side of music-power measurements. After all, hi-fi amplifiers were designed to reproduce music rather than steady-state sine waves. As a matter of fact, this publication has featured several stories by proponents of the music-power system (see "Music-Power Rating—Help or Hindrance?" by Norman H. Crowhurst in our October 1960 issue, and "How to Make Music-Power Measurements" by Daniel R. von Recklinghausen, in our June 1961 issue.) Therefore, although we can appreciate some of the arguments on behalf of the music-power method, for the present, we will stick to our guns.—Editors.

* * *

"TECHNICIAN" AND "ENGINEER"

To the Editors:

I have noted your editorial in the January issue of ELECTRONICS WORLD, and the previous correspondence. May I suggest that you are completely "on the beam," and these editorials should be very helpful in straightening out the confusion which has been created by the meaning of the word "engineer" and "technician" by past years' training of many technician-level engineers by our engineering colleges. This practice, I feel, is disappearing as our engineering colleges become more aware of their real responsibilities to their profession and to our society as a whole.

I would also like to suggest that you are merely a little ahead of time in suggesting that a college degree be a requirement for professional engineering work. This will come, and very soon. Otherwise, engineering can not hope to achieve real status as a profession. The other professions require a degree and additional training beyond the B.S. level, and have for many years.

J. D. RYDER, DEAN
Michigan State University
College of Engineering
East Lansing, Michigan

On the other hand, there are many who feel that the terms "engineer" and "technician" should describe a person's function and not his education.—Editors.

* * *

DOUBLE-CHAMBER ENCLOSURES

To the Editors:

When I first read the article "Double-Chamber Speaker Enclosure" by George Augspurger in your December 1961 issue, I could not help but feel doubtful, since I have seen so many of these "specials" turn out to be unsatisfactory. To make a long story short, I finally decided to try it.

I built two units as my system is stereo. The units were built of ¾" plywood, glued and screwed together. For a trial, I used two inexpensive 8-inch extended-range speakers, and two inexpensive 3-inch tweeters that I had on hand. The first time I tried them I was amazed at their good performance. As a matter of fact, I prefer them to some more expensive units owned by a friend. I have not measured them in any way and don't intend to, as I am more interested in what they sound like, rather than what they measure up or down to.

ARNOLD GOVAIN
Wolcott, Connecticut

To the Editors:

I have received letters from readers inquiring about the design of a double-chamber reflex enclosure for 12-inch loudspeakers. Unfortunately, this involves more than simply increasing the dimensions listed in my article (December 1961 issue).

To fully utilize the capabilities of the larger cone diameter, the tuned frequencies of the enclosure should be set slightly lower than when an 8-inch speaker is used. Frequencies of about 22 and 45 cps should give good results.

Since the uppermost impedance peak should not lie too far above the higher resonant frequency, the larger of the

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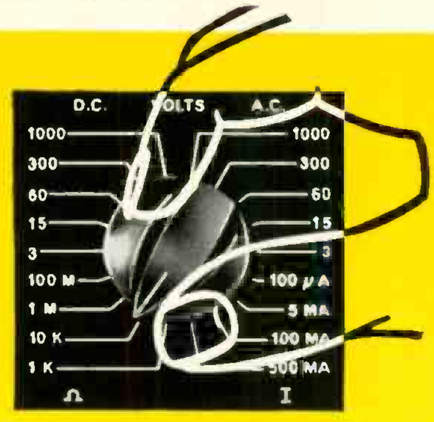

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two chambers should have sufficient volume to keep this impedance peak below 65 cps. For most good, high-efficiency, 12-inch speakers, this means a larger chamber internal volume of 3-4 cu. ft.

The lower tuned frequency of the system is established by the two outer ports in relation to the total size of both chambers. The smaller chamber should probably be about 1½-2 cubic feet in volume, making the total internal volume of the enclosure on the order of six cubic feet.

In such a design, each of the three ports should have a cross-sectional area on the order of 15 square inches, and a duct long enough to set the two, tuned frequencies at the desired points. Offhand, the ducts would probably turn out to be about 10-inches long.

Starting from these rather vague guesses, one would have to construct the enclosure, install the speaker, and then make impedance measurements of the complete system. The lengths of the ducts would be adjusted to set the tuned frequencies at about 22 and 45 cps. (With an extremely efficient speaker, stronger apparent bass might be achieved by tuning the enclosure higher, say, 30 and 55 cps.)

Unfortunately, I have not had the opportunity to build a larger double-chamber enclosure, nor do I expect to be able to do so in the near future. If the constructor has access to an audio generator and a v.t.v.m., he should not be afraid to go ahead with the project since he can adjust its operation by changing duct lengths and checking his results with impedance measurements. This is exactly how I would go about it if I were building such an enclosure.

George L. Augspurger
Chicago, Illinois

Author Augspurger's original article described an experimental hi-fi loudspeaker enclosure that extended bass response of almost any good 8-inch loudspeaker down to a useful 35 cps.

We have been swamped with requests from our readers who want us to re-design the enclosure for their particular 10-, 12-, or 15-inch loudspeaker. Although we would like to help, the enclosure was originally built only for 8-inch speakers so that the only construction information we have is for this speaker size. We hope the above suggestions by the author will be of some help to those of our readers who want to try out such an enclosure for other speaker sizes. We have also heard from quite a few of our readers who have built the enclosure as described and all were very pleased with their results.—Editors.

* * *

PARALLEL-RESISTANCE SHORTCUT

To the Editors:

Mr. Quinn's "Parallel Resistance Shortcut" in the December issue of Electronics World is ingenious and his pragmatic test proves it. However, as my old mathematics teacher used to say, "a thousand proofs that a thing is right are not as good as one proof that it can't be wrong."

So let's dig out our old high-school algebra and see if we can make the latter demonstration.

Our formula for R_1 and R_2 in parallel uses the conductance formula $1/R_1+1/R_2=(R_1+R_2)/R_1R_2$ and the resistance is the reciprocal $R_1R_2/(R_1+R_2)=R_T$.

Now, using Mr. Quinn's formula and retaining R_1, R_2, R_T and adding n representing any number, we were told to do the following to find the values of R_1 and R_2: $nR_T=R_1$, $nR_T/(n-1)=R_2$. The numerator of the fraction for R_T (using the previous basic formula) is $n^2R_T^2/(n-1)$, and the denominator is $[(n-1)nR_T+nR_T]/(n-1)$. This reduces the basic formula to: $n^2R_T^2/[(n-1)nR_T+nR_T]$; dividing by nR_T gives us $nR_T/[(n-1)+1]$ or nR_T/n, which reduces to R_T, and "like the man says," it works.

Extending Mr. Quinn's idea, suppose you have R_1 and you want to arrive at R_T. Consider R_1 as $(R_1/R_T)R_T$, then R_2 will be $[R_1/(R_1-R_T)]\ R_T$.

As an example, you want R_T to be 300 ohms and you have an R_1 value of 800 ohms. What value must R_2 be? $R_1=800=(800/300)\times 300$ or $8/3\times 300$, and $R_2=[8/(8-3)]\times 300$ or $8/5\times 300=480$ ohms.

Lucille Cooke
Seattle, Washington

Reader Cooke's letter proves that Author Quinn's shortcut is certainly worthwhile.—Editors.

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Product Test Report

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G-E VR-1000 Stereo Cartridge
Conar Model 211 Vacuum-Tube Voltmeter
Sencore SS117 Sweep-Circuit Analyzer
"Knight-Kit" Laboratory Oscilloscope

Fisher 500-B FM Stereo Multiplex Receiver

For copy of manufacturer's brochure, circle No. 56 *on coupon (page* 108).

THE *Fisher* 500-B is a complete FM stereo receiver, in one compact unit measuring 17½" wide x 6⅜" high x 14" deep. It contains an FM tuner, multiplex demodulation circuits, and a two-channel audio amplifier rated at 65 watts music-power output. With the addition of a pair of loudspeakers, it becomes a fine FM mono/stereo receiving system. There are input facilities for a magnetic phono cartridge, a tape head, a tape recorder playback amplifier, and a high-level input for a ceramic cartridge, TV sound, or other signal source.

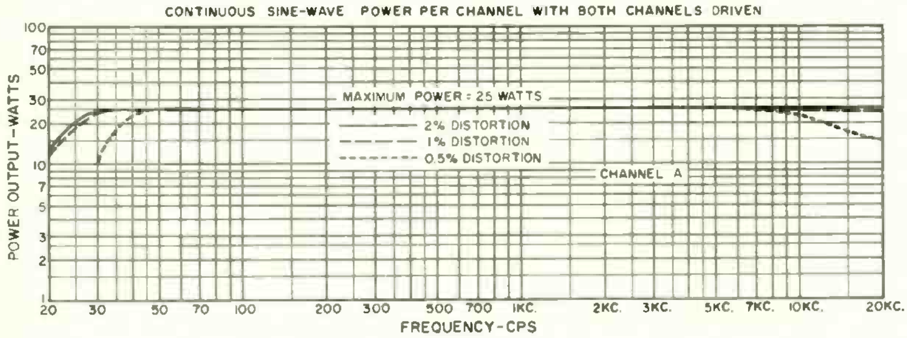
The audio section of the *Fisher* 500-B is exceptionally complete. Each channel uses a pair of 7591 output tubes, with terminals for 4-, 8-, and 16-ohm speakers. A switch on the rear of the chassis reverses the phase of one speaker, which is convenient for initial installation adjustments. Each phono input has its own level control, also at the rear, where it may be set to match the tuner level.

On the front panel are the input selector, with a separate position for FM stereo multiplex, concentric tone controls for the two channels, a stereo balance control, a volume control combined with power switch, the tuning knob, and a multiplex filter switch for noise reduction when a poor signal-to-noise ratio exists. There are also six slide switches, operating the high filter (scratch), low filter (rumble), tape monitoring from a machine with separate recording and playback amplifiers, mono/stereo selection for all inputs, channel reversing, and loudness compensation. It is hard to think of any useful control function which has been omitted from the 500-B.

The following are the results of our tests on the audio section:

Power Output (continuous) at 2% distortion: 25 watts/channel, 50 watts total.

IHFM Power Bandwidth: Greater than 20-20,000 cps.



IM Distortion: 2% at 16 watts per channel output (continuous).

Frequency Response: 30-20,000 cps ± 0.6 db, down 4.8 db at 20 cps.

RIAA Phono Equalization: 30-15,000 cps ± 1 db.

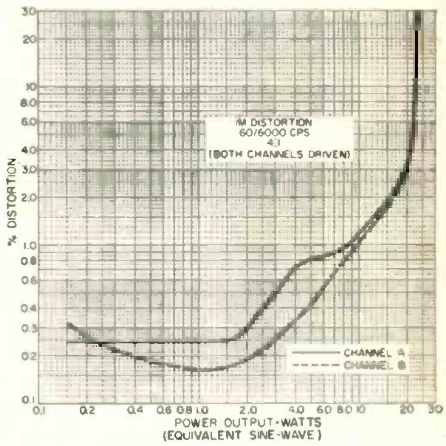
NAB Tape Playback Equalization: 50-15,000 cps ± 1.9 db.

Tone-Control Range: 30 cps, +8.5 db, −12.5 db; 15,000 cps, +10.6 db, −14.2 db.

Sensitivity (for 10-watts output per channel): "Phono" 1.5 mv.; "Tape Head" 0.8 mv.; "Aux." 110 mv.

Hum (referred to 10 watts): "Phono" −69 db; "Tape Head" −54 db; "Aux" −71 db.

The power response of the *Fisher* 500-B amplifiers measured exceptionally flat, with full power available (at 2% harmonic distortion) from 30 cps up to 20,000 cps. The power curve at 1% harmonic distortion was nearly identical to that obtained at 2% distortion, and even at 0.5% distortion over 23 watts per channel could be obtained from 40 to 7000 cps. The IM distortion was under 0.5% for all powers up to 3 watts, which is not likely to be exceeded except on peaks. There was a sharp drop in response below 30 cps, which was accentuated by an additional loss of response below 40 cps on "Phono" and "Tape Head" inputs. This drop is intentional due to the insertion of a fixed subsonic rumble filter. The total loss was not significant above 30 cps and we couldn't hear any loss of bass.



The amplifiers were stable with capacitive loads, and the tubes and capacitors were operated well within their ratings. In spite of the nineteen tubes used in the 500-B, it ran quite cool during extended periods of use. Power-line leakage was under 0.5 milliampere—a negligible value.

The FM tuner had a measured IHFM usable sensitivity of 3.1 μv., compared to its rated 2.2 μv. The difference is well within the limits of normal tube-characteristic variations and measurement errors. The distortion at 100% modulation was under 0.5% for signal strengths over 300 μv. The a.g.c. action was very good, with no measurable change in audio level for signals stronger than 4 μv. About 5 volts is available at the tape output jack from a 100 per-cent

(Continued on page 20)

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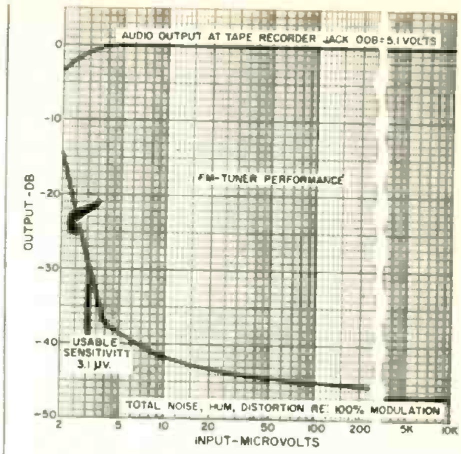

modulated FM signal. Residual FM hum in the tuner was down 52 db from 100% modulation. AM rejection was 50 db, a very good figure. The *Fisher* 500-B has no a.f.c. and we measured a drift of less than 3 kc. in the first 5 minutes from a cold start, increasing to 10 kc. in 10 minutes. This is one of the most stable FM receivers we have yet tested. The frequency response of the FM tuner was ± 1 db from 40-20,000 cps, falling to −10 db at 20 cps.

The multiplex performance of the 500-B was judged by listening to FM stereo broadcasts, since we do not have a multiplex signal generator in the lab at present. The tuning-eye tube, when the selector switch is set for FM stereo, indicates the presence of the 19-kc. pilot carrier, eliminating all guesswork as to whether or not a station is transmitting in stereo. The high sensitivity of the 500-B proved itself when we operated it in a basement, with a folded dipole antenna on the floor, and received excellent, noise-free stereo programs. The sound quality, especially on live or taped broadcasts, left nothing to be desired, with definite channel separation (no blurring of directionality at high frequencies) and no significant increase of noise level over monophonic reception.

Our conclusion is that the 500-B is an excellent basis for a good stereo music system, eliminating at one stroke the matching and interconnection problems sometimes encountered with separate components. It is simple to use, highly flexible, sensitive enough for most locations, and has adequate power for the average listening room with speakers of moderate efficiency.

The *Fisher* 500-B sells for $359.50. It is also available as the Model 800-B, with the addition of an AM tuner section, for $429.50. ▲

G-E VR-1000 Stereo Cartridge

For copy of manufacturer's brochure, circle No. 57 *on coupon* (*page* 108).

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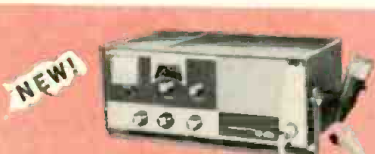

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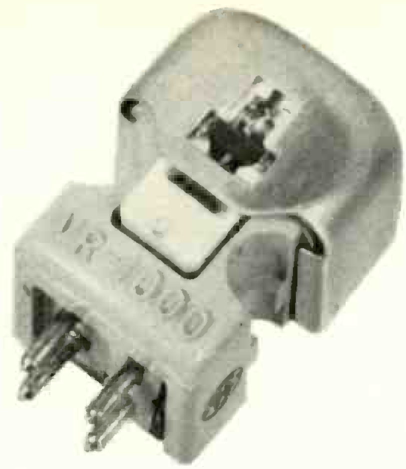


construction and performance, however, they reflect the current state of the art in cartridge design. The cartridge is available in two versions, essentially similar except for their required tracking forces and the compliance and tip radius of their styli.

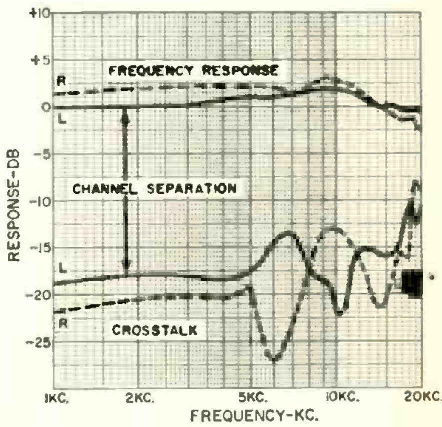
The VR-1000-5, which we tested for this report, has a 0.5-mil diamond stylus and tracks at 1 to 3 grams; the VR-1000-7 has a 0.7-mil stylus and tracks at the 3 to 7 gram forces required by many record changers.

G-E lists the following specifications for the VR-1000-5: lateral compliance, 6×10^{-6} cm./dyne; vertical compliance, 9×10^{-6} cm./dyne; frequency response, 20-20,000 cps ± 3 db; load resistance 47,000 ohms/channel; output, 1 mv./channel/cm./sec. (minimum); channel separation, 25 db (nominal) at 1000 cps; channel balance, 2 db or better at 1000 cps; resistance, 1100 ohms/channel (nominal); and inductance, 400 mhy./channel (nominal).

The new armature design of the VR-1000-5 has very low mass (less than 1 milligram at the stylus tip) and is mounted in a resilient suspension. The armature is part of the magnetic circuit and its motion, whether lateral or vertical, varies the amount of magnetic flux through the armature and the two pole pieces. This variation induces voltages into the coils surrounding the pole-piece extensions.

Our first test of the VR-1000-5 was to determine the optimum tracking force. The large 32-cps amplitudes on the *Cook* Series 60 record were tracked nicely at 2 grams. The 30 cm./sec. velocities (at 1000 cps) on the *Fairchild* 101 record were a little too high to be tracked without distortion and some symmetrical clipping of the waveform was observed. However, forces higher than 1 gram did not improve the results from this record. We made all subsequent measurements with a 2-gram tracking force.

The *G-E* frequency response ratings are based on the use of the *RCA* 12-5-71 test record. We used this in addition to the *Westrex* 1A, which we have used in the past, along with the new *CBS Laboratories'* STR-100 record. With any record, the response of this cartridge was outstanding for flatness and freedom from peaks. The curve shown is the one using the *RCA* test record and



indicates a response within ±1.5 db from 1000 to 15,000 cps. This variation was not exceeded all the way down to 20 cps with the other records.

The 1000-cps output was approximately 7.5 mv. at 5 cm./sec. The channels were balanced to within 1.5 db at all frequencies. Crosstalk was about 20 db up to 5 kc., better than 13 db up to 17 kc., and 7.5 db at 20 kc. Hum shielding was only moderately effective, in spite of triple Mumetal shielding. (It is very difficult to completely shield variable-reluctance cartridges, where the armature is part of the magnetic circuit.) We did not find any audible induced hum in our tests, however, and no such problems should be encountered with any good turntable.

The VR-1000-5 has a clean, extended high end which can really be appreciated when using a very-wide-range loudspeaker and good records. There is no fuzziness at high levels, and instrumental separation is exceptional. Needle talk is moderately low. The good stereo separation at all frequencies results in a well-defined spatial sense, with no tendency for instruments or vocalists to wander from side to side.

The price of the *General Electric* VR-1000-5 is $29.95. The VR-1000-7, for record changers, sells for $24.95. ▲

Conar Model 211 Vacuum-Tube Voltmeter

For copy of manufacturer's brochure, circle No. 58 on coupon (page 108).

ONE of the most useful pieces of test equipment on the service bench is the v.t.v.m. This is the instrument that the technician usually turns on in the morning and keeps on throughout the day so that he can take d.c. and a.c. readings on circuits with minimum loading. Advantages of the Conar Model 211 v.t.v.m. kit, which we have just assembled and tested, are its utter simplicity, lack of frills, and ease of construction. These characteristics not only make the meter easy to build (it took us only 6 hours), but, once completed, there is little to go wrong.

Unlike most v.t.v.m.'s, which use either three test leads or a switchable probe, this meter uses only two test leads for all measurements. There

(*Continued on page* 71)

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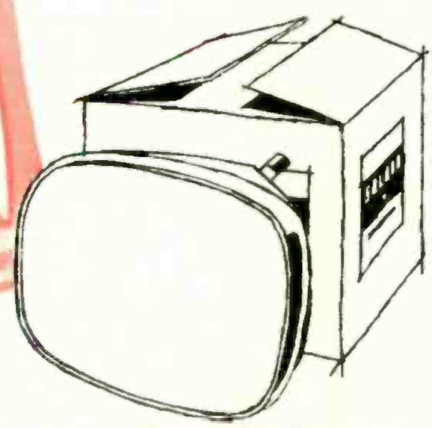

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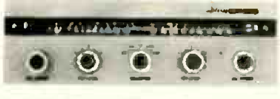

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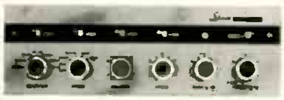

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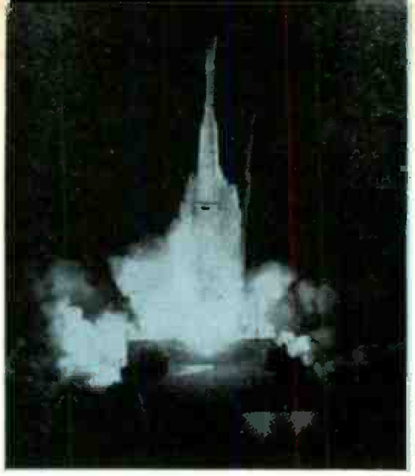


electric engines for outer space

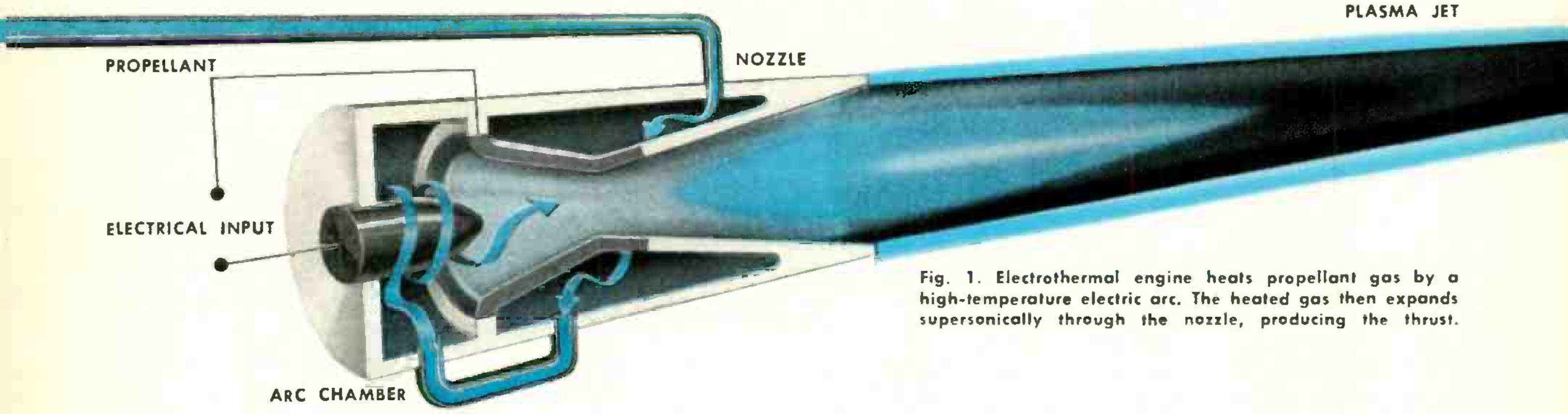


Fig. 1. Electrothermal engine heats propellant gas by a high-temperature electric arc. The heated gas then expands supersonically through the nozzle, producing the thrust.

SOMETIME within the next year, if all goes well, a four-stage Scout rocket will blast off from a launching pad at Wallops Island, Virginia, and hurl into space a payload which may prove to be the most important since Sputnik I went into orbit. Installed in the nose of the Scout will be the first electrical rocket propulsion units to be tested in actual flight.

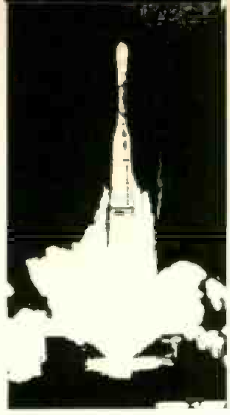
These advanced electrical space engines—already successfully bench-tested in a dozen or more scientific laboratories around the country—promise to open up a new era in space travel. Unlike today's fuel-hungry chemical rockets which burn tons of fuel in seconds and exhaust themselves in one mammoth push, the new electrical engines will operate for days, months, or even years, consuming only moderate amounts of fuel. Thus, they will make possible extended, fully powered flight into deep space.

The electrical space engines achieve their tremendous fuel economy by operating in a way quite different from today's chemical rockets. Nevertheless, the basic principle of propulsion on which they work is the same as that which propels an Atlas or a Fourth of July rocket. Any rocket—chemical or electrical—is a reaction motor. It pushes itself ahead by shoving something else backwards. A jet aircraft engine, which operates the same way, sucks in huge quantities of air, then shoves the air backwards to propel itself. A space rocket, operating in a vacuum, has no air to shove, so it must throw some of its own mass overboard in order to move.

In all chemical rockets the mass thrown backwards is the combustion product of the rocket's burning fuel. The force which throws these gases backwards is the combustion of that same fuel. This system works well enough, as evidenced by the fact that it has put scores of satellites and a couple of men into orbit. But it has severe limitations. Worst is its insatiable propellant

Beams of ions and jets of gaseous plasma will be used to propel future space vehicles on long interplanetary trips. Here are details on some of these engines soon to be tested.

By KEN GILMORE



appetite. To make maximum use of every pound of propellant, engineers try to increase propulsion efficiency in several ways. Propulsion is proportional to the rate of flow and the velocity of the expelled matter. In other words, the more pounds per second of mass expelled, or the faster the expulsion velocity, the more propulsive power realized from every pound of fuel. The amount of propellant available for expulsion is limited by the fuel capacity of a rocket. Thus, about the only way to increase the efficiency of an engine is to expel the propellant at a higher velocity.

The velocity of expulsion, in turn, is dependent on the engine's operating temperature. Modern chemical rockets run, for the most part, in the vicinity of 7000° F. At this temperature, most chemical bonds between elements have been destroyed, so a rough upper limit to combustion temperature is established at this point. To put it another way, chemical rockets have about reached the limit of their efficiency.

How efficient is the fuel?

Engineers calculate the efficiency in terms of specific impulse—that is, the ratio of thrust produced to the rate of mass (fuel) consumed. To define it differently, specific impulse is a measure of how much thrust is realized from every pound of fuel. It is expressed in seconds, and can be thought of as the amount of time a pound of propellant would last if burned at a rate which would continuously provide one pound of thrust. The higher the specific impulse, the more thrust from every pound of fuel. Best current rocket fuels achieve a specific impulse of approximately 300 seconds.

Mass & energy, one package or two?

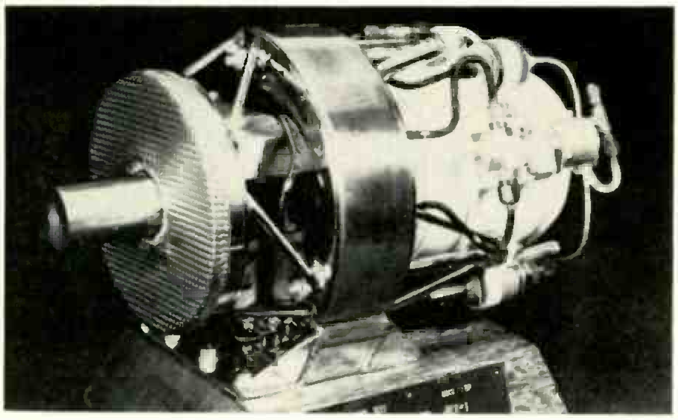
Chemical rockets combine both the mass to be expelled and the source of energy to do the expelling in one package; that is, the liquid or solid fuel burns, and simultaneously expels its own combustion products. But there is no inherent reason why some other source of power could not be used to expel a mass specifically designed as a propellant. The proposed atomic rockets now being developed will work on that principle. Since they will use nuclear power as a heat source, they can use hydrogen as a propellant. Hydrogen has an extremely high specific heat index; that is, a great ability to store thermal energy. Its expansion and acceleration are consequently higher than the combustion gases of present fuels.

Although atomic rockets will be somewhat more efficient, they will still be held to the same approximate temperature limits as chemical rockets, and for the same reasons. Thus the specific impulse of an atomic rocket will be about the same as that of a chemical rocket.

Both the chemical and atomic rockets are "impulse" type engines; power plants which generate large amounts of thrust. They can easily produce up to several pounds of thrust per pound of weight. But they supply it for only a brief time, since the fuel, which has a relatively low specific impulse, is expended rapidly. For really long space journeys—to the planets, for example—we will need engines which can achieve far more efficient use of propellant.

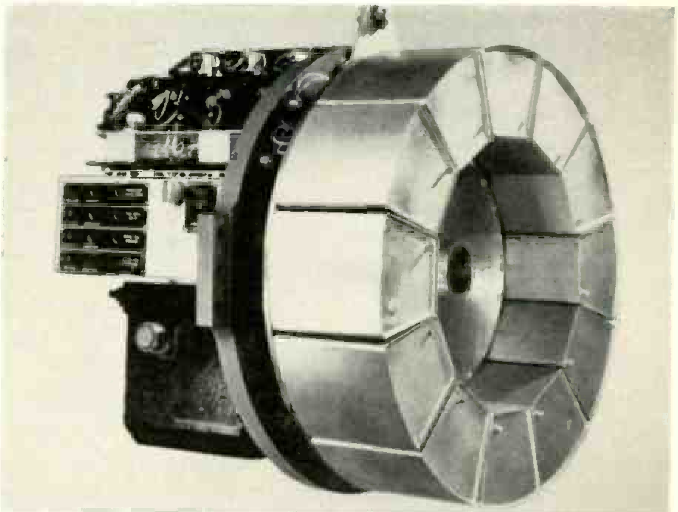
The answer: electrical space drives

At present, the best bet for a radically increasing specific impulse seems to lie with the electric engine. Using electrical



▲ This Plasmadyne Corp. arc-jet engine weighs 12 pounds complete with fuel, delivers a fraction of a pound of thrust, and is not much bigger than a football. It may be used to nudge space satellites into exact orbit and for other precise space functions.

Close-up of battery-powered pinch-plasma space engine. The engine obtains its thrust from the acceleration of nitrogen. A ring of 12 capacitors, charged to 3000 v., discharges through the gas in the nozzle to provide the thrust that is required. ▼



◀ Technician in environmental space chamber makes pressure adjustment on plasma space engine developed by Republic Aviation. The engine is designed to operate in space indefinitely on its own battery power. Batteries are recharged by means of solar cells.

COVER PHOTO

THIS month's cover shows a technician at Hughes Aircraft Company's research laboratories in Malibu, California, readying an ion engine for a test run in a space chamber. The engine, developed for the National Aeronautics and Space Administration, vaporizes the rare metal cesium and accelerates its ionized atoms to produce thrust. The company has run the engine in its high-vacuum chamber, and NASA will test it in an actual space flight some time this year. (Photo: Courtesy Hughes Aircraft Co.)

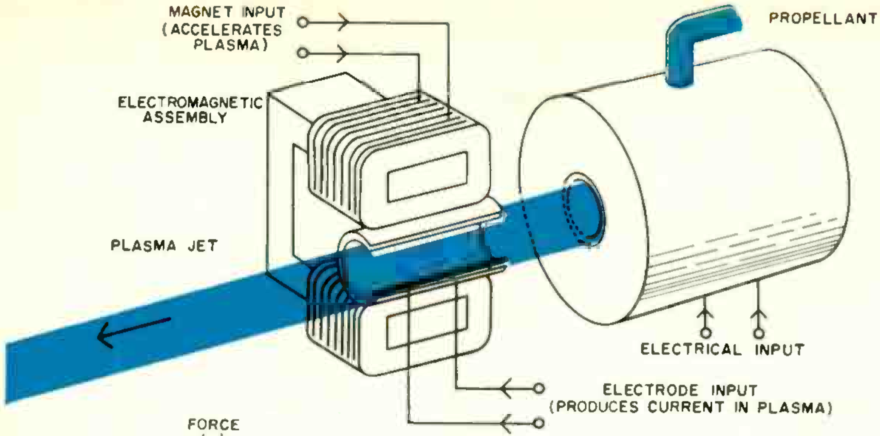


Fig. 2. Basic electromagnetic space engine. Current is made to flow in a gas plasma and a magnetic field is produced. This interacts with an externally produced magnetic field to accelerate the plasma and produce thrust.

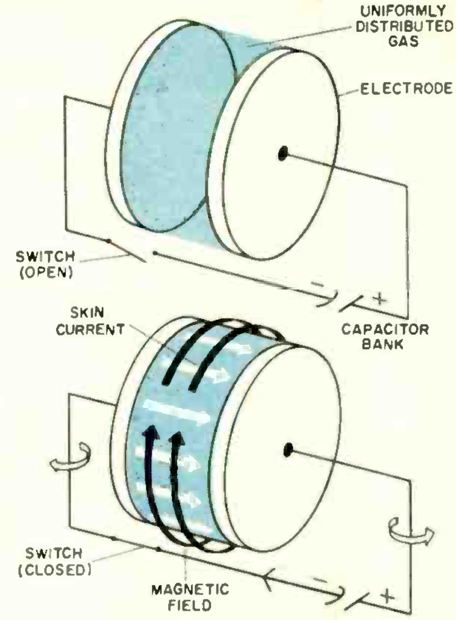


Fig. 3. When the switch is closed, the gas between the plates ionizes and current begins to flow, discharging the capacitor bank. The current flows principally at the outer periphery of the discs. As with any current flow, a magnetic field occurs.

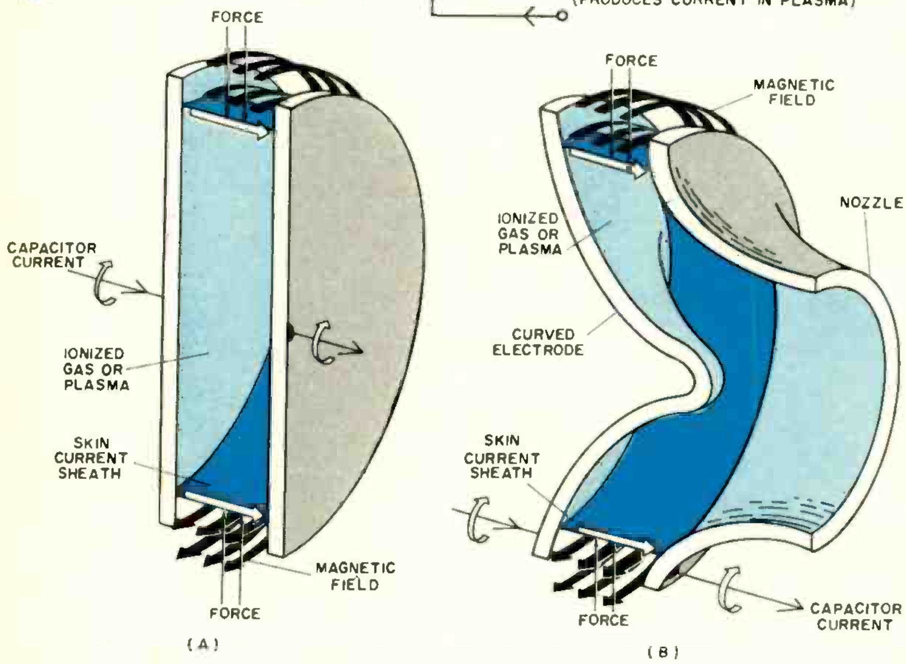


Fig. 4. (A) Cross section of disc electrodes showing how magnetic field produces forces that "pinch" the ionized gas inward. (B) If electrode shape is changed and an opening provided, the pinch effect forces the gas out of the nozzle opening and produces thrust. In this case an additional, external magnetic field is not required at all.

—rather than purely thermal—means of accelerating the propellant as it speeds backwards from the ship, the electric engine expels propellant at tremendous speeds. Consequently, it gets many times—in some cases, thousands of times—as much thrust from every pound of propellant as can be achieved by purely chemical means.

An electrical space rocket's unique operating principles, of course, result in an engine with completely different performance characteristics. All electric space engines, for example, are inherently low-thrust devices. Where current chemical rockets produce hundreds or thousands of pounds of thrust, electrical rockets will produce, at most, a few hundred or a few thousand pounds. Operating prototype models, as a matter of fact, produce only fractions of pounds. But where chemical rockets operate at best for a few minutes, electric engines will run for hours, days, months—perhaps, eventually, for years. And of course, since the specific impulse is high, they get many times the *total* thrust from a given amount of fuel.

No resistance in space

Although an electric rocket with its low thrust will probably never be used to lift a space vehicle from the surface of a planet, it can still be an extremely useful device. Once a ship gets into space, it is essentially a floating body. No power is needed to hold it up. When it moves, there is no friction. To get it moving, or to change its course, only the forces of inertia need to be overcome. Thus, the application of only a few pounds of thrust over a period of time will accelerate even a large ship to fantastic speeds. Once a space ship is put into orbit around Earth with a chemical or nuclear rocket, it could easily be propelled to an orbit around, say, Mars or Venus, with an electrical engine of only a few pounds thrust. The longer the journey to be undertaken, the greater the advantages of the highly efficient electrical engines.

Present-day electrical space drives fall into three general types: electrothermal, electromagnetic, and electrostatic. Each has its own combination of advantages and drawbacks.

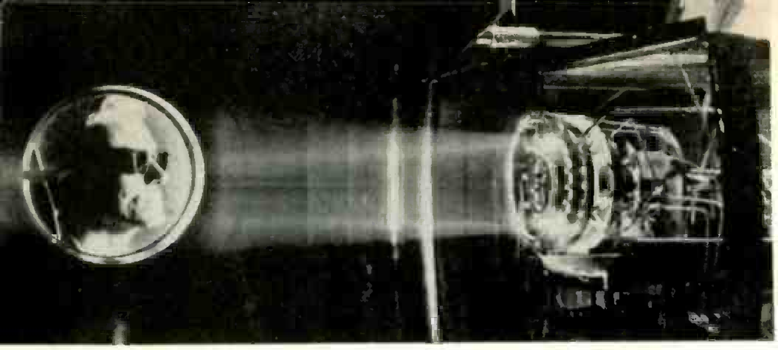
The electrothermal engine

This space engine is a first cousin to today's chemical rockets. In essence, it uses an electric arc—much like that produced by an arc welder or a movie projector—to heat a propellant gas. The gas expands rapidly and is expelled at high speeds. The temperature of the arc can be in the vicinity of 20,000° to 30,000° F., so that much higher exhaust velocities can be obtained than with chemical rockets. Specific impulses ranging up to 2000 seconds have been achieved with laboratory models.

The big difficulty is cooling. Fig. 1, a diagram of an electrothermal—or arc jet engine, shows one method of achieving reasonably good results. The incoming propellant is drawn in around the nozzle, cooling it.

Electromagnetic engines

It has long been known that as a gas reaches the temperature of about 20,000° F., it begins to ionize. That is, the orbital electrons of the gas molecules become detached. These floating electrons carry a negative charge, while the electron-short nuclei—or ions—are positively charged. This ionized mixture—called plasma—is electrically neutral, since all of the electrons and ions are present. But, because it has so many



The glow of ionized atoms shooting out of a working ion engine is viewed by a technician through a porthole in a space-simulation chamber at Hughes Aircraft laboratories. Although the thrust being tested here is less than a tenth of a pound, a cluster of larger engines operating on the same principle could be used to propel heavy payloads over interplanetary distances.

charged particles, it is a very good conductor of electricity.

Any current-carrying conductor—including plasma—generates a magnetic field around itself. The magnetic field can react with an external field and produce mechanical force. This force is used to drive electric motors. It can also propel space ships. If a current-carrying plasma is subjected to a magnetic field at the proper angle, it can be accelerated right out of the rear of a space ship, thus shoving the space ship forward. Fig. 2 shows one simple way of doing this. A plasma is generated, sent on to the electromagnetic assembly. There, a current flows across the plasma from one electrode to another, creating a magnetic field around the plasma. This field reacts with the field of the magnet and the plasma jet shoots from the rear of the engine.

The extra boost given to the plasma by the magnetic assembly raises the specific impulse of the engine to a range between 2000 and 4000 seconds.

The plasma pinch

Other basic configurations of electromagnetic engines have also been worked out to apply the same principles in different ways. Of the several demonstrated methods of accelerating plasma, one of the most ingenious is the "plasma-pinch" engine, developed by *Republic Aviation Corporation*. To understand its operation, consider the case of the two disc-shaped electrodes connected in series with a switch and a capacitor bank (Fig. 3A). Between the electrodes is an evenly distributed low-pressure gas. The electromagnetic "pinch" begins when the switch is closed. Enough voltage is applied to the electrodes to literally tear electrons from the gas molecules, thereby ionizing the gas and changing it to a plasma.

Plasma is an excellent conductor of electricity, of course, so a current begins to flow from one plate to the other, discharging the capacitor. The current growth is extremely rapid, and is accompanied by a growing self-induced magnetic field. The current distribution that develops in the plasma is illustrated in Fig. 3B. The current is maximum at the outside and decreases sharply toward the center of the cylinder. This is called "skin effect."

The magnetic field is outside the "skin" current, or current sheath, with no field inside of it. This magnetic field tends to produce a "pinch," or force toward the axis of the cylinder (Fig. 4A). The effect is as if the current sheath were a heavily stretched elastic band compressing and accelerating the plasma inward. This sheath has been called a "magnetic piston" since it acts much the same as would a solid piston carrying the plasma before it. With the two discs as shown, the plasma is compressed and heated to a high temperature at the axis. It does no work. In order to make use of this phenomenon to propel a space ship, some arrangements of plates is necessary to exhaust the high-pressure plasma in one direction. Fig. 4B shows one such configuration. As the pinch proceeds inward, the gas is forced out of the nozzle at high velocity. Fig. 5 shows an actual nozzle cross-section based on this principle. (*Continued on page* 66)

TYPE	ELECTRO-THERMAL	ELECTROMAGNETIC	ELECTROSTATIC
Principle of operation:	Propellant gas heated by electricity and expanded supersonically through nozzle	Three principal types: 1. Traveling wave accelerator. Plasma accelerated by traveling magnetic waves. 2. Plasma gun. Current flows through plasma setting up magnetic field. This field interacts with external magnetic field to accelerate plasma. 3. Pinch plasma. Contracting magnetic field created by current flow in plasma used to discharge plasma through nozzle.	Electrically charged particles (ions) accelerated by electrostatic field.
Among those doing development work:	Avco General Electric Giannini Controls NASA Plasmadyne Corp.	Borg Warner Fairchild Stratos General Electric Lockheed Aircraft Los Alamos Scientific Laboratory NASA Republic Aviation Stevens Institute of Technology Temple University University of California Radiation Lab. (Livermore)	Aerojet-General Convair Curtiss-Wright Electro-Optical General Electric Goodrich-High Voltage Hughes Martin NASA Rocketdyne Thompson Ramo Wooldridge United Aircraft

Table 1. Summary of three main types of electric space engines.

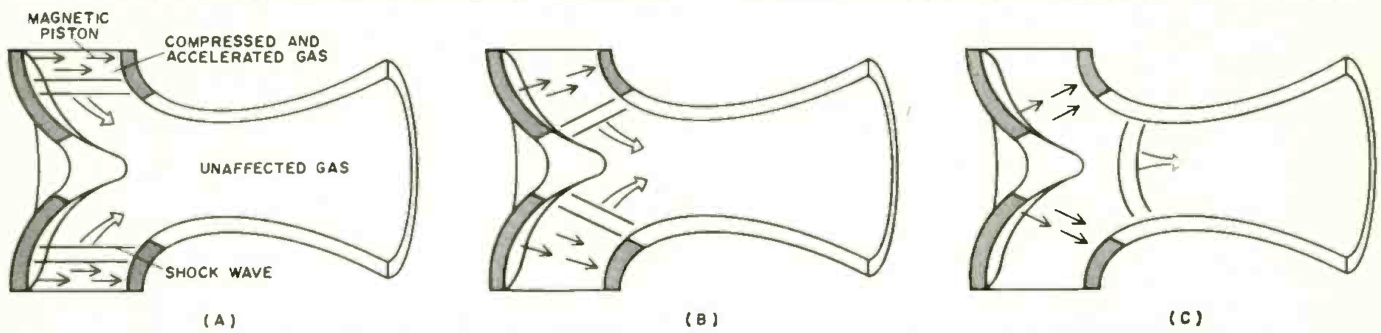
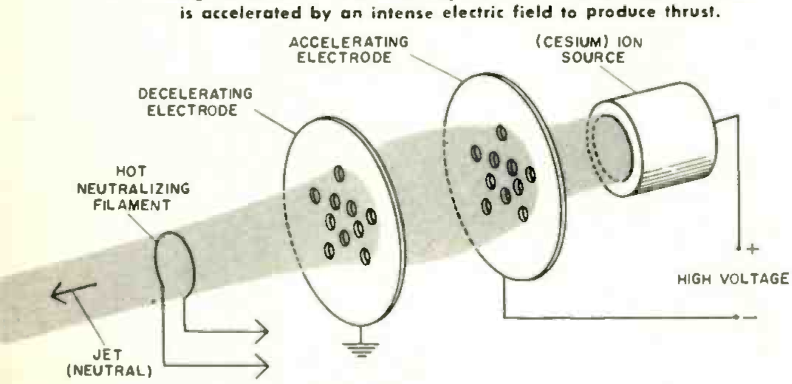
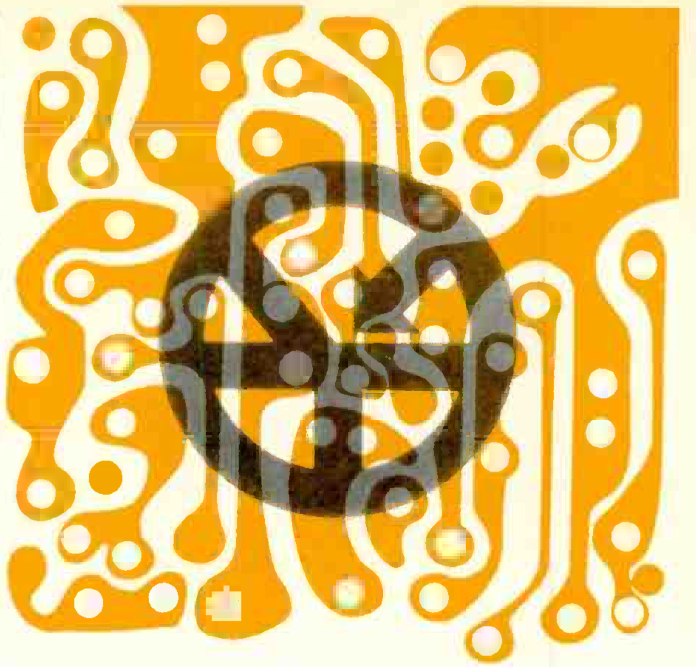


Fig. 5. Conditions within the nozzle of a pinch-plasma electromagnetic engine shown at successive instants of time.

Fig. 6. In the electrostatic engine, a beam of positive ions is accelerated by an intense electric field to produce thrust.



TROUBLESHOOTING TRANSISTORIZED DIGITAL CIRCUITS



By CYRUS GLICKSTEIN

Universal, step-by-step techniques are made possible by the use of standardized, plug-in circuit cards.

LABORATORY and production technicians working with digital transistor equipment (logic-circuit modules) have developed a number of quick-check troubleshooting techniques. Some of these checks highlight basic, logic-circuit action. Reviewing these procedures thus may be helpful not only for technicians interested in servicing digital equipment but also for those interested in becoming more familiar with logic circuitry.

Logic circuits are the basic building blocks of digital computers as well as of an increasing amount of non-computer digital equipment. Logic circuits include transistor unity amplifiers (inverters and emitter-followers), flip-flops, binary counters, diode matrices, and a variety of gates—*and, or,* and *nor*.

Digital equipment is generally modular, consisting of many plug-in, printed-circuit cards. A typical card is shown in Fig. 2. A digital sub-assembly in which the cards are used appears in Fig. 1. Cards having the same types of circuit are usually similar and interchangeable. For example, a single card may consist of two or three flip-flops, with each flip-flop connected to its own circuit through the plug-in connector. Interchangeable cards reduce the number of spares required and simplify replacements.

One of the important advantages of modular construction is the ease of servicing in the field. A defective card can very often be localized quickly by internal test circuitry in the digital equipment, or by an external test instrument, such as an oscilloscope, used in signal tracing at specified test points. The defective card is then removed and replaced by a known good card and the unit is restored to service with a minimum of down time. Depending on the installation—including type of installation, repair philosophy, and repair facilities available—the defective card may be discarded, repaired at the installation, or forwarded to another area for repair.

However, troubleshooting defective cards is standard procedure in electronics laboratories and in production testing. Usually, an adapter card is used. The defective card is removed, the adapter card inserted in its place, and the defective card is then inserted in the adapter (Fig. 3). The latter is a printed-circuit card connecting each jack in the socket on top of it to the corresponding pin on the plug at the bottom of the card. This is a simple method for connecting the suspected card to its own socket while keeping it above the level of the surrounding cards so that troubleshooting checks requiring source voltage can be made readily. When necessary, resistance tests are generally made with the suspected card completely removed from the equipment.

A thumb-nail review of transistor action in logic circuitry will clarify the reasons for various troubleshooting checks. In logic circuits generally, transistors operate in only two ways: they are either fully conducting or completely cut off. And each transistor stage usually operates alternately cut off and conducting, depending on the required circuit action at a given instant. A transistor stage becomes inoperative if (1) it continues to conduct when it should be cut off (internal short or external circuit defect) or (2) it is cut off when it should be conducting (open transistor or external circuit defect).

One of the first steps in troubleshooting a defective stage, therefore, is to determine if the transistor is good or if the trouble is elsewhere in the stage. Unlike vacuum-tube circuits, where it is a simple matter to substitute a known good tube and re-check the circuit, it is not advisable to substitute transistors indiscriminately. In most cases, the transistor leads are soldered to the card. Indiscriminate substitution, therefore, by unsoldering old transistors and soldering on new ones would be time-consuming and may damage the transistors or the card. It is obviously preferable to determine beforehand, wherever possible, if a transistor is defective before removing it from the circuit and substituting another.

One method of checking for a good transistor is use of an in-circuit transistor checker, which permits testing the

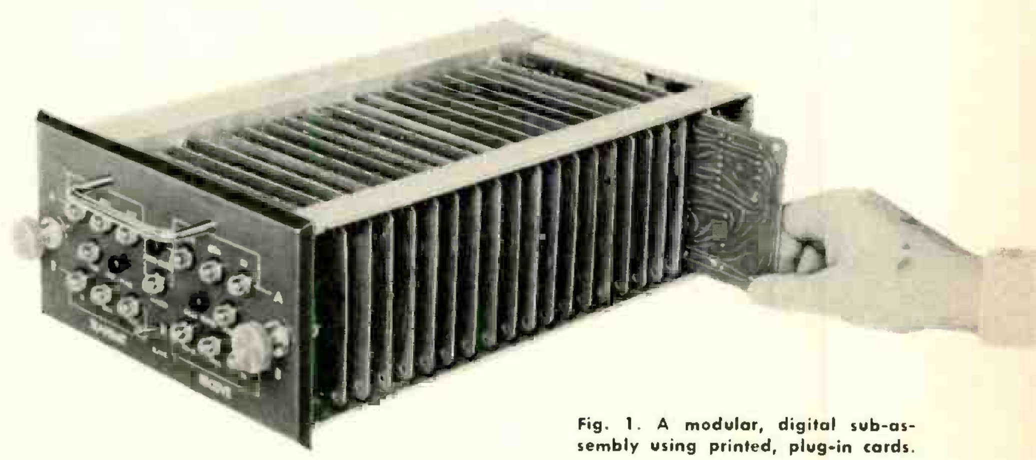


Fig. 1. A modular, digital sub-assembly using printed, plug-in cards.

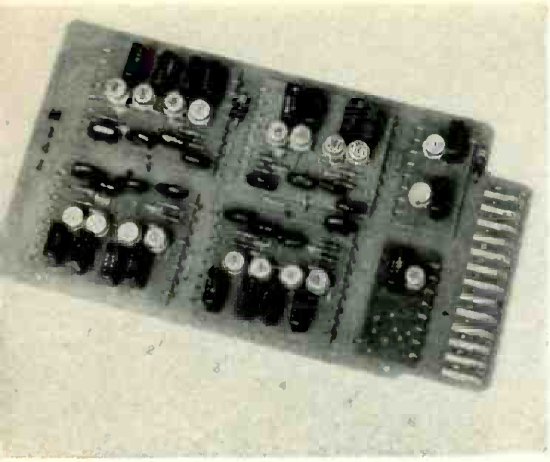


Fig. 2. A typical digital plug-in card.

suspected part without removing it from the circuit. However, a series of quick checks, using a voltmeter, can usually be performed faster.

In troubleshooting an inverter or emitter-follower stage, three simple troubleshooting steps are followed:

(1) Make a source-voltage check to determine if correct voltages are being applied to the stage.

(2) Make a voltage check around the transistor electrodes (emitter, base, and collector) to determine if the transistor is conducting or non-conducting—or if any unusual potentials are present.

(3) If normal potentials are present for either a conducting or a non-conducting transistor, check to find if the transistor can be made to change states—made to conduct if previously non-conducting, or *vice versa*. That is, a check is made to determine if the transistor can operate normally both in the conducting and non-conducting states.

As a concrete illustration of these steps, let's troubleshoot a typical *p-n-p* inverter stage suspected of being defective (Fig. 4). An inverter is a unity amplifier: an amplifier with a gain of 1 whose output is inverted in polarity from the input signal. A "logic 1" signal (−7 v.) applied to the input circuit at the base produces a "logic 0" (0 v.) at the collector; a "logic 0" at the base produces a "logic 1" at the collector. (Digital systems vary in the values and polarities assigned to "logic 1" and "logic 0" signals. The values and polarities cited are typical but not universal.)

The emitter is connected to ground (0 v.); the collector is returned to −12 v. through a load resistor, and the base is connected to the junction of a voltage divider returned to a positive potential. With 0 v. (a "logic 0" signal) applied to the input, the stage is cut off by the positive bias applied to the base. Therefore, with the transistor cut off, normal potentials around the transistor electrodes are:

Emitter	0 v.
Base	+1 v.
Collector	−7 v. ("logic 1" output)

(Although the transistor does not conduct, −7 v. rather than the full −12 v. is obtained at the collector because output of the latter is loaded by other stages. However, if the cards containing these other stages are removed, the reading is −12 v.)

On the other hand, with a −7 v. signal ("logic 1") applied to the input, the transistor stage conducts heavily. Normal potentials around the electrodes are:

Emitter	0 v.
Base	0 v.
Collector	0 v. ("logic 0" output)

Actually, both the base and the collector voltage readings are a fraction of a volt negative, but for practical purposes in troubleshooting, the voltages can be considered ground potential. Obviously, if no source voltages were applied to the stage, the same zero voltages would be read around all the electrodes.

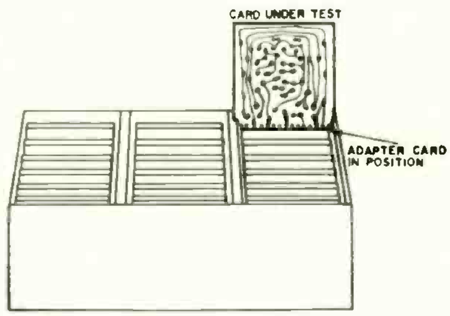


Fig. 3. Defective card is exposed for in-circuit testing with an adapter card.

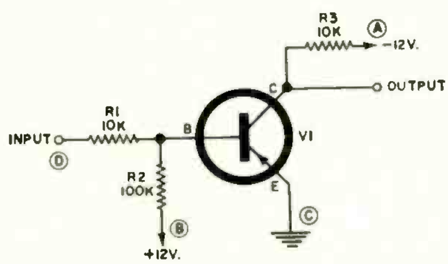


Fig. 4. Typical inverter unity amplifier.

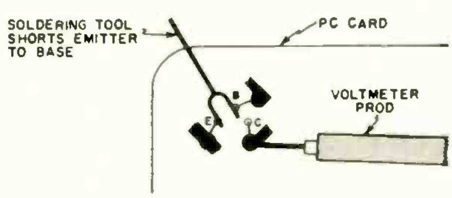
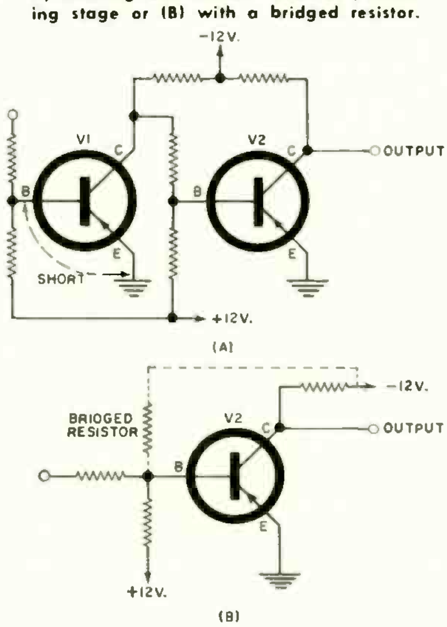


Fig. 5. Effect on the collector voltage is checked when emitter is shorted to base.

Fig. 6. V_2 is checked for conduction (A) by shorting emitter-base diode of preceding stage or (B) with a bridged resistor.



The first step in troubleshooting by voltage measurements, therefore, is to determine if correct source voltages are being applied to the stage. This is done by measuring the voltages at *A*, *B*, and *C* in Fig. 4. Assume the applied voltages are found to be correct: −12 v., +12 v., and 0 v. respectively. A further preliminary check is made at the input, *D*. Assume the input is −7 v.; the stage should be normally conducting. A voltage check around the electrodes is then made and all three electrodes measure 0 v. This indicates the stage is responding correctly to the applied signal. However, one important test must still be made to verify if the transistor can operate normally: Will the stage *stop* conducting when no forward bias is applied to the base? In other words, is the transistor shorted?

A simple way to check is to use a two-prong soldering tool (Fig. 5) or a small screwdriver to short the emitter to the base. The voltage at the collector is then measured while the emitter is still shorted to the base. The transistor should now be non-conducting and the normal −7 v. for a non-conducting stage should be measured at the collector. If 0 v. is still measured here, the transistor is probably shorted. If a check of the schematic indicates no other circuit breakdown can produce 0 v. at the collector with the given set of applied voltages, the transistor is evidently defective and should be replaced.

As a second illustration of troubleshooting procedure, let's assume now that we have the opposite case when voltage checks are made around the stage. Correct supply potentials are present at *A*, *B*, and *C* and a "logic 0" (0 v.) appears at the input (Fig. 4). The stage should, therefore, be non-conducting. Sure enough, the normal potentials for a non-conducting stage are measured around the electrodes: 0 v., +1 v., and −7 v. at the emitter, base, and collector respectively. As before, the acid test is to determine if the stage can operate in the opposite state. In this case: Will the stage conduct normally with a "logic 1" applied to the input? The "logic 1" can be supplied simply by causing the *preceding* stage (V_1 in Fig. 6A) to be cut off by shorting its emitter to its base. If this procedure is not convenient or possible, a resistor can be bridged from the base of the suspected transistor itself (V_2 of Fig. 6B) to the −12-volt supply while collector voltage is measured. Typical resistor value for this purpose is 10,000 ohms, but a higher or lower value may be necessary, depending on circuit parameters. Collector voltage should drop to 0 v., indicating that the stage is conducting. If the stage does not conduct when forward bias is applied to the base through the bridging resistor, the transistor is probably open.

Sometimes voltage readings immediately indicate a defective transistor. For example, supply voltages are normal at *A*, *B*, and *C*, and a "logic 1" (−7 v.) is applied to the input, but the transistor is non-conducting (collector voltage close to −7 v.). Or again, supply voltages are normal, and a "logic 0" (0 v.) is applied to the input, but the transistor collector indicates conduction by a 0-v. reading.

Troubleshooting an emitter-follower is performed in exactly the same way as in an inverter stage. An emitter-follower is a unity amplifier with a gain of 1, where the output is taken from a resistor in the emitter circuit and there is no inversion of signal in the output compared to the input. Checks are made of supply and electrode voltages and further checks are made to determine if the stage can be made both conducting and non-conducting (not at the same time, of course). The only point to keep in mind is that in a normally conducting *p-n-p* emitter-follower (Fig. 7), collector voltage is −12 v., base voltage −5 v., and emitter voltage −5 v.; in a non-conducting emitter-follower, the collector, base, and emitter voltages are −12 v., +2 v., and 0 v. respectively. (The *n-p-n* transistor inverters and emitter-followers are checked by the same technique, keeping in mind the difference in voltage polarities.)

In all of the voltage checks described to this point, it is advisable to disable normal signal input to the stage being checked to prevent interference with the testing. This can be accomplished by front-panel switching (in some equipment), by disabling a preceding stage in the signal path (shorting base to emitter), or by removing the card providing the signal input to the stage being tested.

Flip-Flops and Counters

Quick troubleshooting checks can also be made in transistor flip-flop and counter circuits. In digital equipment, a single flip-flop may be used for a specific control action (Fig. 8) or a series of flip-flops may be used in a binary chain for counting (Fig. 9). Normally, one side of a flip-flop is conducting and the other side is non-conducting. A transition of the correct polarity ("logic 1" or "logic 0," depending on the circuit) applied to the conducting side cuts it off and makes the associated stage conduct.

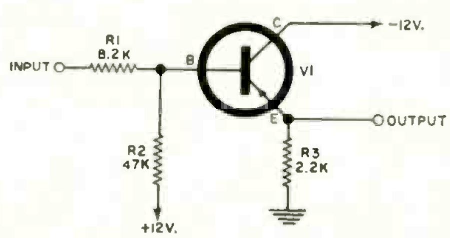


Fig. 7. A typical "p-n-p" emitter follower.

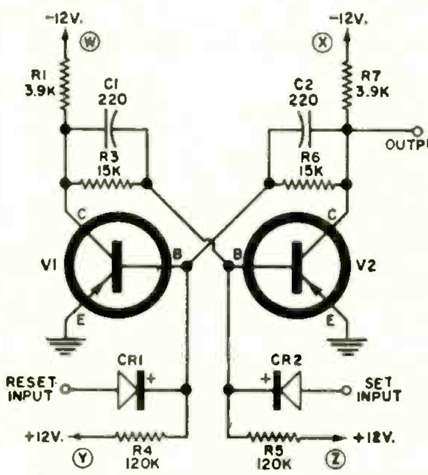


Fig. 8. A typical "p-n-p" flip-flop stage.

A flip-flop is not operating properly if: (1) both sides are conducting simultaneously, or (2) both sides are simultaneously non-conducting, or (3) one side is non-conducting and the other side conducting but the flip-flop will not reverse states when an appropriate signal is applied to the input.

Troubleshooting a flip-flop suspected of being defective is very much like troubleshooting an inverter stage, for the first two steps. Then an additional quick check is made. The general procedure is:

(1) Check to determine if correct source voltages are being applied to both sections of the flip-flop.

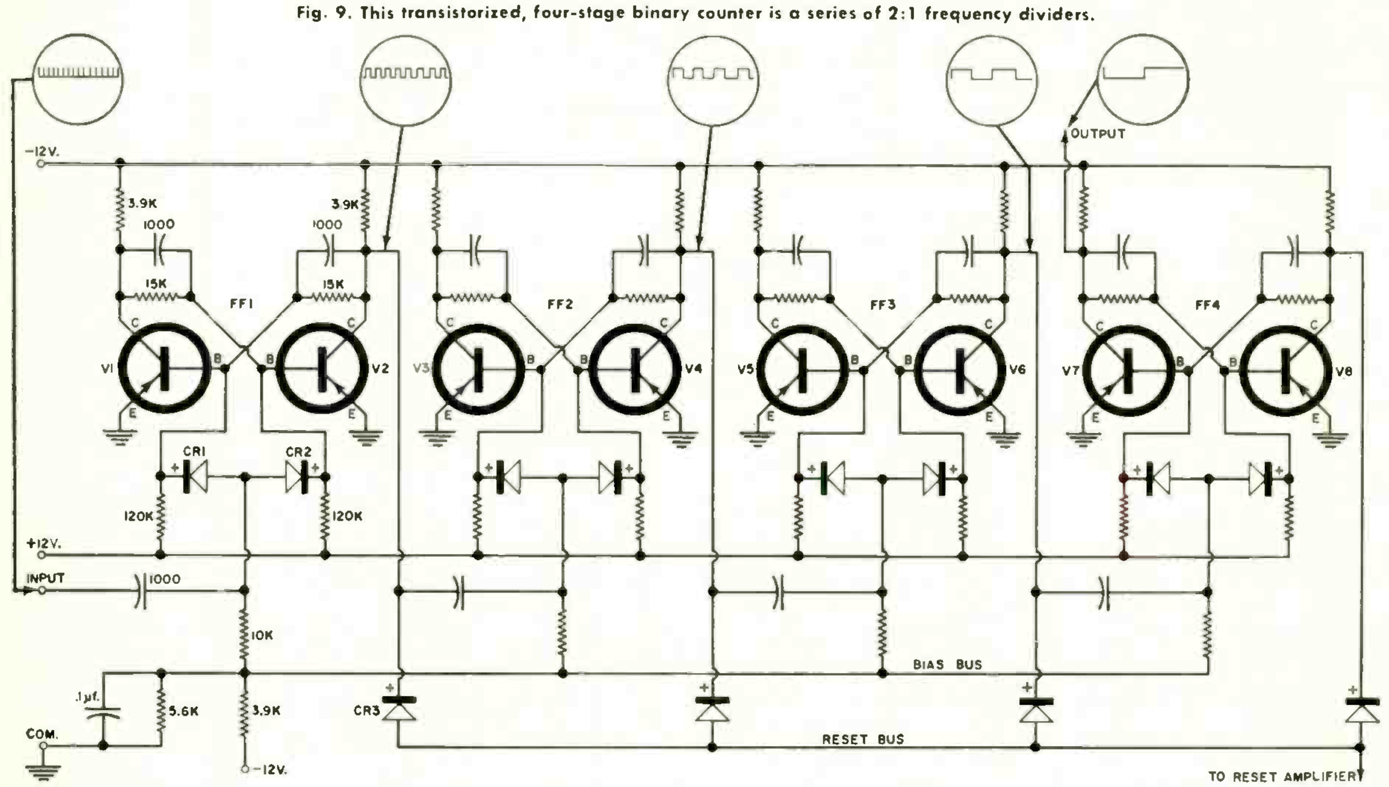
(2) Make a voltage check around the electrodes of both transistors to determine if each is conducting (or non-conducting) and if any unusual potentials are present.

(3) If one is conducting and the other non-conducting (the normal condition for a flip-flop), check to see if the flip-flop can reverse states. If both are conducting or both non-conducting, check to see if each one individually can be made to reverse states. Specific examples will clarify how these checks are made.

The typical *p-n-p* flip-flop shown in Fig. 8 is being checked to determine if it is operating properly. Correct source voltages are measured at points *W*, *X*, *Y*, and *Z* (−12 v., −12 v., +12 v., and +12 v. respectively). Voltages are measured around the electrodes of each

(*Continued on page* 83)

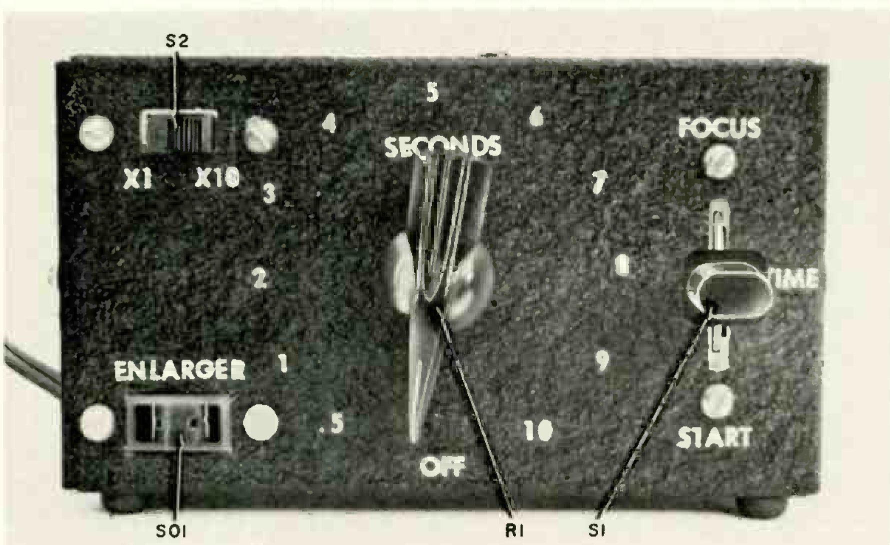
Fig. 9. This transistorized, four-stage binary counter is a series of 2:1 frequency dividers.



TRANSISTORIZED DARKROOM TIMER

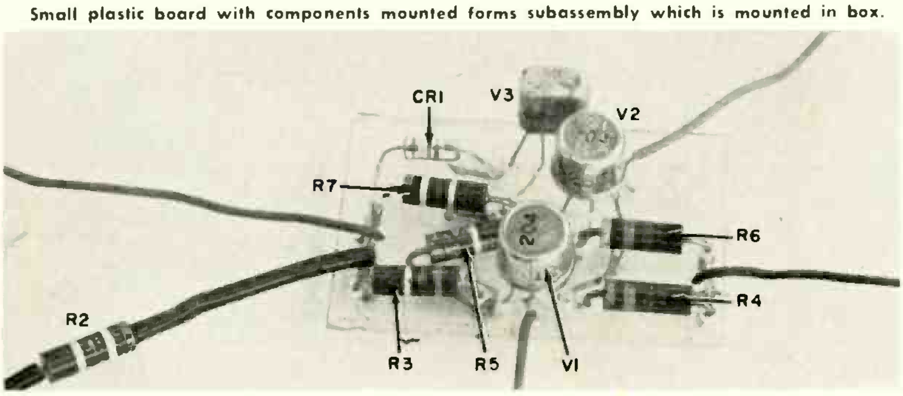
By STANLEY E. BAMMEL

Complete construction details on a simple photographic enlarger timer with settings from .5 to 100 seconds.



Front-panel view of the enlarger timer which provides a wide range of timed intervals.

Small plastic board with components mounted forms subassembly which is mounted in box.



ELECTRONIC timers have several advantages over mechanical timers, including freedom from mechanical breakdown and greater versatility as to timing range and uses. Transistors offer several additional advantages as compared to the use of tubes. The possibilities of miniaturization, portability, and reliability cannot be equaled with tube circuitry.

This timer lends itself to special applications where complete portability and/or battery operation is needed. In addition, total cost of this unit, with new parts, is less than $15.00 with reasonably careful shopping.

Circuit Operation

The basic circuit of the timer is a Schmitt trigger. When the input voltage to a Schmitt trigger is greater than a certain amount, it is in one of two stable states. When the input voltage is below a certain level, it is in the other stable state. A capacitor, C_1 or C_2, is connected (see Fig. 1) across the input and allowed to charge. When the charge reaches a certain level, the Schmitt trigger changes from one stable state to the other.

In use, depressing S_1 ("Start" position) shorts the timing capacitor and completely discharges it. Releasing S_1 places the capacitor across the input and starts the timing cycle. During the timing cycle, V_1 is off and V_2, V_3, RL_1, and one's enlarger (or whatever else is plugged into the timer) are on. The timing capacitor is charged through R_1 and R_2. The rate of the charging and, therefore, the length of the timing cycle are determined by the setting of R_1.

V_1 presents a leakage resistance which is effectively in parallel with R_1 and R_2. This resistance is temperature sensitive. However, with the transistor the author used, this resistance was large enough to have a negligible effect on operation. Other transistors of the same type were tried and have worked as well. However, since inexpensive transistors such as those specified are well known for a wide tolerance in manufacturing, one may encounter a transistor with too much leakage to be ignored. In that case, other transistors must be tried until one is found which has a negligible effect. In addition, V_1 should have a *beta* (current gain) greater than approximately 25.

While, theoretically, one could reverse battery polarity and use *n-p-n* transistors for V_1 and V_2 and a *p-n-p* transistor for V_3, this is not recommended. Experiment showed that inexpensive *n-p-n* transistors have much greater leakage than *p-n-p* units, therefore the majority of *n-p-n* units had too much leakage for this application.

CR_1 keeps leakage current of V_3 very low when it is turned off but also allows it to conduct heavily when on. CR_2 protects V_3 from a relatively high voltage pulse when it turns off abruptly. Without CR_2, V_3 will be destroyed after a short period of use.

Relay RL_1 closes with only 1.75 volts applied to it and opens at less than 1 volt. With new batteries, it has about 2.5 volts applied when it is turned on; therefore, the timer will work even after battery voltage has dropped considerably. Also, since the current drain is low (5 ma. when on and 1 ma. when off) battery life is long.

If battery voltage is increased, a less sensitive relay can be used. Battery voltage can be increased to as much as 6 volts without any other circuit changes being necessary.

Construction & Calibration

Construction is simple and straightforward. The photographs should tell most of the story. One picture shows how small parts are mounted on a small polystyrene board while Fig. 2 shows how the relay is mounted. It is necessary to insulate the relay from the chassis since it is connected to one side of the a.c. line. S_1 should be mounted so that the downward position has the spring return.

After the timer is constructed, it must be calibrated. Electrolytic capacitors are generally made with quite wide tolerances; therefore, it is best to calibrate the X10 range first. It is then simpler and less expensive to make the X1 range conform to calibration by adding or subtracting capacitance than *vice versa*.

To calibrate the X10 range, plug into the timer a desk lamp or other device which gives a readily detected indication of being on. Then simply operate the timer and by trial and error find the settings of R_1 which gives 100 sec., 10 sec., and 5 sec. The rest of the calibrations can be interpolated.

To calibrate the X1 range, set R_1 to 5 sec. and increase or decrease the capacitance of C_1 as required. An increase in capacity increases time and conversely. To increase capacitance, place a relatively small capacitance in parallel with C_1. A trick which can be used to decrease capacitance is to place C_1 in series with C_2. If that is not sufficient, use a smaller capacitor in the first place.

Operation

Using the timer is simple. Set S_2 to the desired range and R_1 to the desired number of seconds and push S_1 down. In the down position S_1 has a spring return. When S_1 is released, the timer turns on and remains on the number of seconds for which it is set. To turn the timer on for an indefinite length of time, push S_1 up ("Focus" position). In this position, S_1 does not have a spring return and will hold.

When the battery is initially turned on, C_1 or C_2 must charge. As it charges, the timer is on just as in the normal timing cycle. After the first range is charged, switching to the other range will do the same thing. After the initial charging, this will not happen again unless there is a very long period of time between changing ranges. During such a long period, the capacitor will discharge through its internal resistance.

Relay contacts are rated at 2 amps into a resistive load. Therefore, the enlarger or other device plugged into SO_1 must not draw more than this much current. Hence, the total wattage of the enlarger lamp employed should not exceed 250 watts. ▲

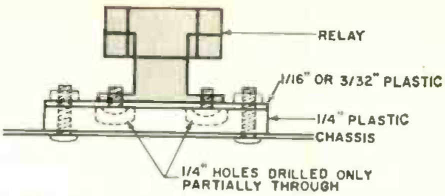
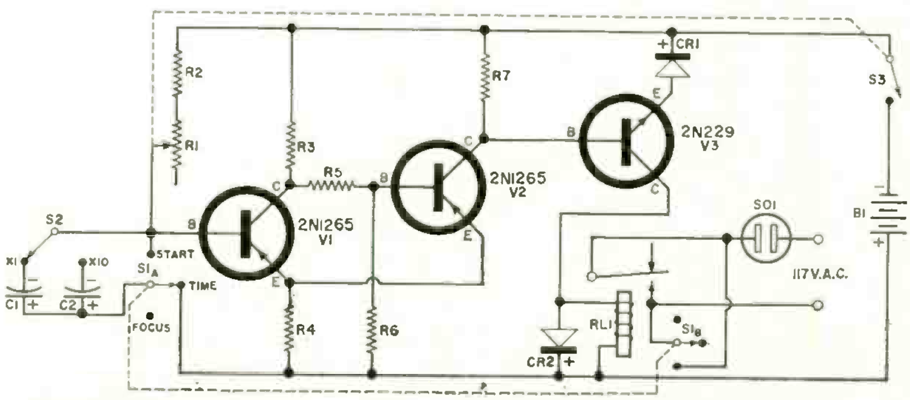


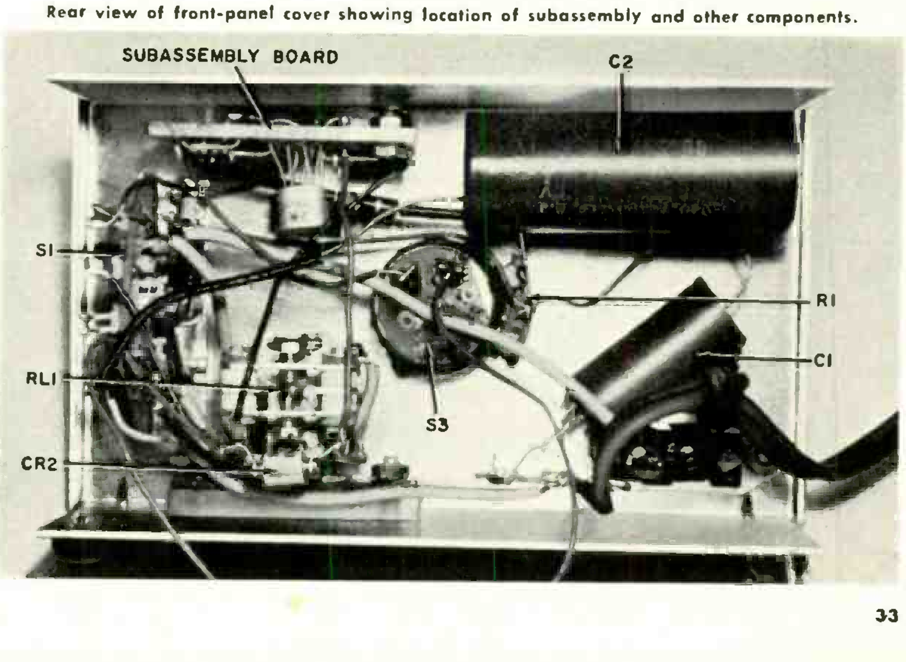
Fig. 2. Details showing relay mounting.



R_1—50,000 ohm linear taper pot
R_2, R_7—3900 ohm, ½ w. res.
R_3—2700 ohm, ½ w. res.
R_4—3300 ohm, ½ w. res.
R_5—1500 ohm, ½ w. res.
R_6—4700 ohm, ½ w. res.
C_1—100 µf., 6 v. elec. capacitor (see text)
C_2—1000 µf., 6 v. elec. capacitor (see text)
CR_1, CR_2—Crystal diode (1N60, 1N295, etc.)
S_1—Lever action switch; d.p. 3-pos., one-pos. spring return (Centralab 1467)
S_2—S.p.d.t. slide switch
S_3—S.p.s.t. switch (on R_1)
RL_1—S.p.d.t., 500 ohm, 4.5 ma., 10 mw. relay (Kurman 51CA37D, 5D1CA37D, or equiv.)
SO_1—A.c. receptacle
B_1—3-volt battery (two penlite cells in series)
V_1, V_2—2N1265 or other general-purpose "p-n-p" transistor (see text)
V_3—2N229 or other general-purpose "n-p-n" transistor (see text)

Fig. 1. Circuit diagram of the transistorized timer which employs a Schmitt trigger.

Rear view of front-panel cover showing location of subassembly and other components.



New Electrical Effect in Semi-Metals ▶

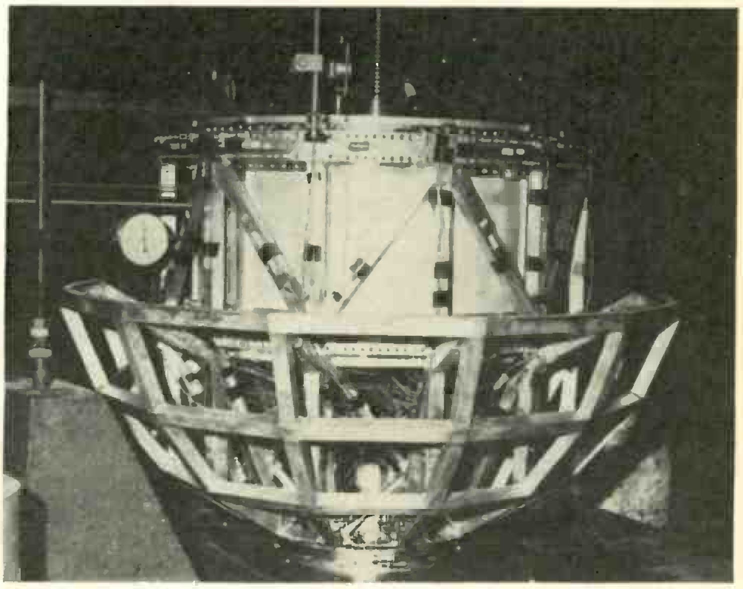
Dr. Leo Esaki, of the IBM Research Center, *is shown adjusting apparatus used in his discovery of a new electrical effect in bismuth, a semi-metal. At low temperatures, close to absolute zero, with strong electric and magnetic fields applied to a single crystal of ultra-pure bismuth, it was found that the semi-metal did not follow Ohm's Law. Instead an abrupt change or "kink" appeared in its characteristic conduction as the fields reached a certain strength. Also, the velocity of charged particles in the material seems comparable to the sound velocity in bismuth. Further research into the cause of this effect may lead to future higher speed computers.*

First Tests of Communication Satellite

Stripped of its outside cover of thousands of solar cells and a belt of microwave receiving and transmitting antennas, the Bell System's *satellite "Telstar" is being tested by a Lehigh University research team. The world's first broadband active communications satellite is scheduled for launching some time this spring. The satellite was subjected to static-load tests which simulated the actual rigors anticipated during its acceleration into a 7000-mile high orbit. In the tests, several tons of loads were applied in various directions to the 34" sphere.*

▼

RECENT DEVELOPMENTS IN ELECTRONICS



Synthetic Quartz

A large crystal of quartz, grown in a twenty-one day period by Transcom Electronics *of Newport, R.I., is shown below. High heat and pressure are required for the growing process. The company is licensed by* Western Electric, *developer of the technique, to supply companies outside of the* Bell System *with the man-made quartz.*

▼

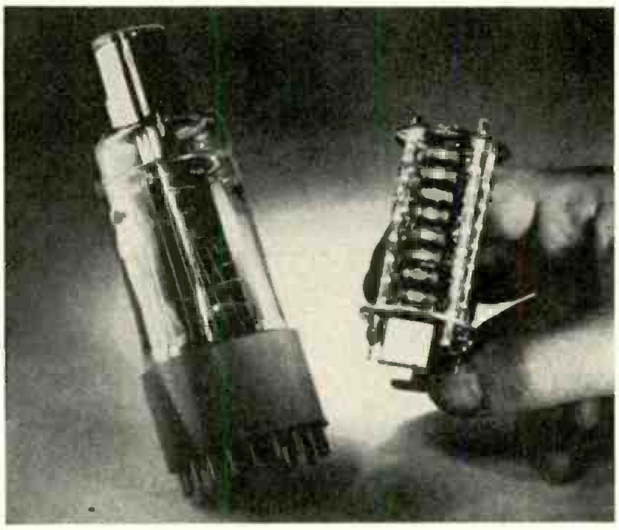
Computer for BMEWS

A Sylvania *field engineer is replacing a logic board used in the memory unit of the Air Force's Ballistic Missile Early Warning System computer complex. Special circuits are employed to analyze radar echoes that signify the presence of missiles, predict the time and area of impact.*

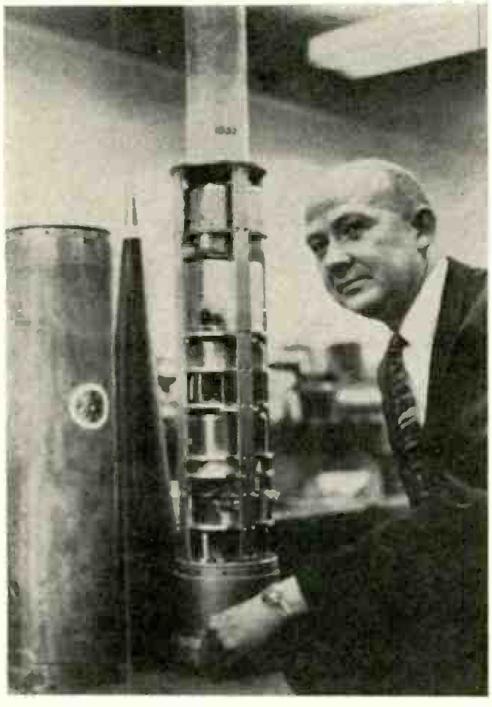
▼

▲ **Color-TV Pix Tube Plant Expansion**
Helping to accelerate production of color-TV picture tubes is this solder-application machine at RCA's $10-million Lancaster, Pa. plant where a $1.5-million expansion program is underway. The machine spreads a thin ribbon of special glass-sealing solder on the edge of the rotating envelope. The solder bonds the tube's faceplate, containing the color screen, to the funnel portion.

▲ **Satellite-Antenna Support**
A giant 70-foot wheel, machined to greater precision for its size than a fine watch, is craned into vertical position at the Bell System's *satellite station in Andover, Maine. The wheel weighs 40 tons and will be used to orient a huge antenna for experiments in satellite communications, which will begin with the launching of the "Telstar" experimental satellite (shown being tested on the facing page) this spring. The construction project is protected from the Maine winter by an inflated shelter seen overhead.*



▲ **Tubeless Tube for Space**
A tubeless electron tube (right), designed for spacecraft and satellites, that operates without the familiar glass envelope of conventional tubes, has been developed by ITT. *Since the vacuum in outer space is far greater than that obtainable on earth, an envelope is not required to enclose the tube elements. The tube shown is a multiplier phototube that generates a signal when light shines on it. By eliminating the glass, no filtering of impinging light occurs so that a wider sensitivity may be produced. The new tube is rugged enough to withstand rocket firings. A conventional multiplier phototube is at the left.*



◄ **Ionosphere Measurement**
An electronics technique for studying plasmas (ionized gases) has been adapted for use with sounding rockets to perform a direct probe of the lower regions of the ionosphere. The technique was developed by Geophysics Corp. of America. *Electrodes on the nose and side (circled) of the "Nike-Cajun" rocket shown measure electron density and temperature at altitudes between 50 and 90 miles and telemeter this information to ground observers.*

MULTI-OUTPUT TV TEST GENERATOR

By JOHN POTTER SHIELDS

Variable-frequency spiked or saw-tooth pulses in either polarity are produced by a simple tester.

BECAUSE it can be used to perform so many useful jobs in a radio-TV service shop or in most other establishments where electronics is involved, and because it is so simple and potentially compact a device, the neon oscillator described here should appeal to many users. It is a combined pulse-output and saw-tooth generator, whose frequency may be adjusted. Furthermore, the basic circuit comprises only three resistors, three capacitors, one neon lamp, and a d.p.d.t. switch.

As a pulse generator, it can produce a series of equally spaced, short-duration pulses with fast rise time and reversible polarity. Applied to the control grid (or cathode) of a TV receiver's picture tube, it can be used to check and adjust deflection linearity. The pulse output can also be used to check on the linearity of a scope's horizontal-sweep circuits, as a source of timing or marker pulses, or as a source of constant-amplitude trigger pulses. Operated as a saw-tooth generator, it makes an excellent substitution drive signal for checking the horizontal-sweep section of a TV receiver. It also makes a good substitute for the sweep oscillator in an oscilloscope, emergency or otherwise.

The basic generator is shown schematically in Fig. 1A. A source of d.c. voltage, anywhere from 90 to 150 volts, is applied through polarity-reversing switch S_1 to the arm of potentiometer R_1. The potentiometer is connected in series with R_2 to one terminal of the NE-2 neon lamp, PL_1 and also to one terminal of C_1. The other terminal of the bulb is connected through R_3 to the other terminal of C_1, which is brought out at point A. Capacitors C_2 and C_3 provide d.c. isolation to output terminals C and B.

In operation, when d.c. voltage is first applied, C_1 charges through R_1 and R_2 until the voltage across the capacitor is sufficient to fire the neon lamp. The charging time is determined by the setting of R_1. At the instant PL_1 fires, a very brief pulse appears across R_3. It has the waveshape shown in Fig. 2A. This pulse voltage appears between terminals A and B.

The saw-tooth output, obtained directly across capacitor C_1, is produced by the gradual build-up of charging voltage at this component and the collapse of the voltage when the neon lamp fires. It is taken off between terminals A and C.

The construction of the basic generator is extremely simple. All parts are readily obtainable. All or some of them may very well be on hand before the constructor is ready to start. The values of the three capacitors and three resistors may vary more than 20 per cent without appreciable change in the performance of the unit. With those values shown, the generator can be varied over a portion of the range of audio frequencies. With some experimentation, the range can be altered.

Since current consumption of the generator is very slight, it is practical to operate the device from batteries, if the user so desires. One of the smaller 90-volt batteries, like the *Eveready* 479, will permit building generator and battery into a single case while maintaining reasonable size. Because there is nothing critical about the circuit and because different users will choose different power-supply arrangements, no layout is given for the instrument.

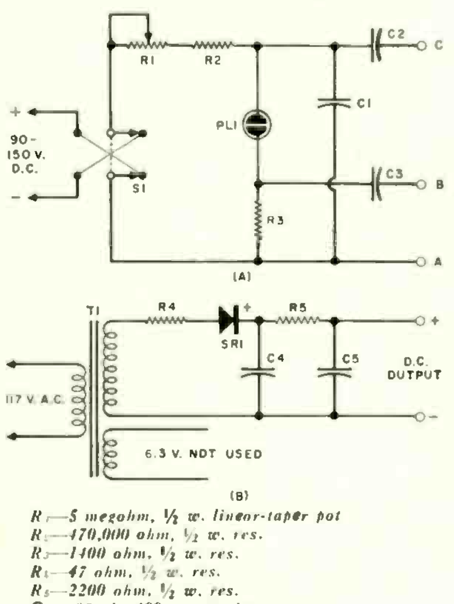
Where independence from an external source of power is not important, the user may elect to build the small power supply shown in Fig. 1B and to incorporate it with the generator. The transformer listed happened to be handy and, although the filament secondary is not used, is worth consideration because of its low cost. Any reasonably priced, low-current 1:1 transformer at line voltage would serve to provide isolation. Similarly SR_1, although it can pass more current than is needed, is inexpensive. Any low-current rectifier that can handle line voltage will do. An "on-off" switch can also be added, or a 3-position switch can be used for S_1, with one position used to turn the instrument off.

To check the sweep linearity of a scope, simply connect terminal A to the scope ground and terminal B to the vertical input. Adjust the generator's frequency control (R_1) and the scope's sweep-frequency and vertical-gain controls until approximately eight to ten pulses of convenient height appear on the CRT screen. If the pulses appear evenly spaced, the scope's sweep is linear. It is best to repeat this check at different settings of the scope's frequency control.

To check vertical linearity in TV, connect terminal A to receiver ground and terminal B (an insulation-piercing type of test clip is most convenient) to the grid or cathode lead from the CRT socket. The schematic can be checked to see whether grid or cathode drive is used, or each can be tried for proper operation. This can be done while a low-level, received signal (contrast control at a low setting) is used to synchronize the vertical circuits. R_1 is adjusted for a stationary pattern of ten to twelve horizontal bars. Then height and vertical-linearity controls are adjusted for uniform thickness and spacing of the bars.

To use as a scope's sweep-frequency oscillator, connect terminals A and C to the instrument's horizontal-amplifier input. The generator now controls the scope's sweep rate. To check a TV horizontal-sweep section, connect terminal A to receiver ground and a test clip or prod to terminal C. The probe can now be used to inject the saw-tooth signal into various portions of the sweep circuit.

These are only a few possible applications. Others will occur to the user once he has become familiar with operation. ▲



R_1—5 megohm, ½ w. linear-taper pot
R_2—470,000 ohm, ½ w. res.
R_3—1400 ohm, ½ w. res.
R_4—47 ohm, ½ w. res.
R_5—2200 ohm, ½ w. res.
C_1—.05 μf., 400 v. capacitor
C_2, C_3—.1 μf., 400 v. capacitor
C_4, C_5—20 μf., 150 v. elec. capacitor
PL_1—NE-2 neon lamp
S_1—D.p.d.t. toggle or rotary switch
SR_1—130 v. r.m.s. input, 50 ma. rectifier (Sarkes Tarzian Type 50 or equiv.)
T_1—Isolation trans. 117 v. pri.; 125 v., 15 ma. sec.; second winding not used. (Stancor PS-8415 or equiv.)

Fig. 1. The basic oscillator (A) uses eight common components. The optional power supply (B) is no more elaborate.

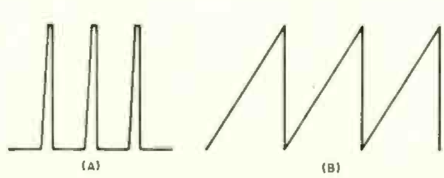


Fig. 2. The two basic output waveforms.

REVERBERATION

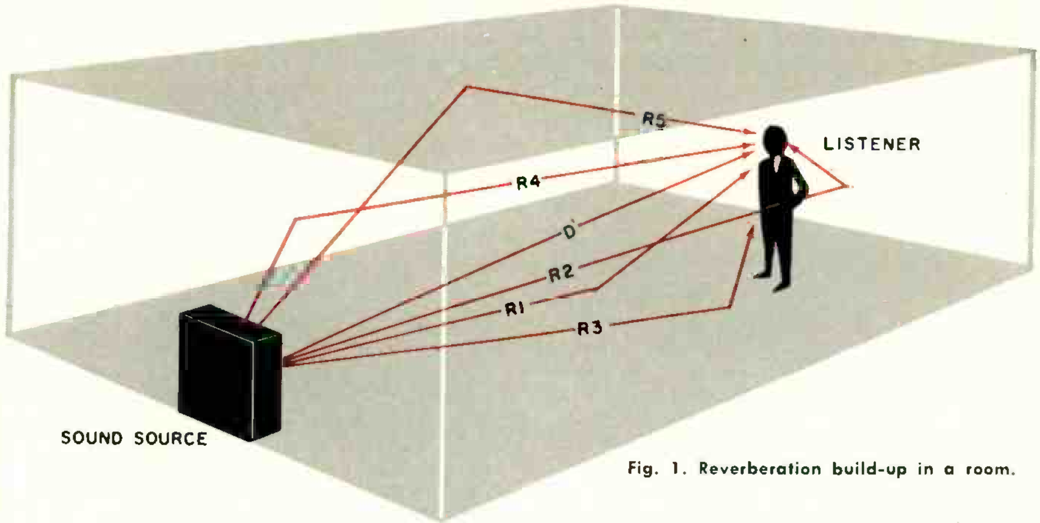


Fig. 1. Reverberation build-up in a room.

IN AUDIO REPRODUCTION

By STEVEN HAHN / Round Hill Associates

The importance of reverb for hi-fi and a survey of methods in current use for achieving this effect.

WHENEVER a sound is made in an enclosed area, such as a room or a concert hall, it takes a certain amount of time for the sound to become completely inaudible. This effect is called "reverberation" (or decay time); in other words, it is the persistence of sound after the sound source has stopped. The reverberation time of rooms and halls is the amount of time it takes for a given sound to diminish 60 db. This is a sound pressure of one-thousandth or a sound power of one-millionth of the original value.

The actual reverberation time for different rooms can vary widely. An average living room filled with sound-absorbing rugs and drapes usually has a reverberation time of no more than .2 second, while a 10,000-cubic-foot auditorium with highly reflective concrete walls may have a reverberation time as high as 10 seconds.

Most human listening takes place in enclosed areas and, consequently, our ears have become accustomed to reverberation and can clearly distinguish its presence or absence. For example, the spaciousness and fullness of a choir recital in a church is partially due to the comparatively long reverberation time which such a building has. On the other hand, we expect a subdued, almost muffled sound when we talk to our friends in the confines of a heavily carpeted living room with its fairly short reverberation time.

Let us see how the reverberation effect actually develops. Fig. 1 shows a typical three-dimensional enclosure, such as a room, in which there is a sound source and a listener. Assume that the sound source produces a brief, transient burst, such as a gunshot, and then becomes silent. The sound travels out into the room in all directions. The first sound which reaches the listener's ears (*D*) travels the shortest direct path between the sound source and the listener. The second sound which reaches the listener's ears is the echo or reflection which travels the shortest distance (*R1*). As one can see, a number of reflections (*R2, R3, R4*, etc.) will continue to arrive at the listener's ears until the sound dies away.

The reason why the sound finally does die away is that each succeeding echo bounces over greater distances, losing more and more energy in the air through which it travels and to the sound-absorbing, echo-reflecting walls. Thus, the reverberation time is not only dependent upon room volume, but also upon the sound absorption characteristics of the walls and room contents.

Sounds of different frequencies are absorbed by different amounts by the same substance (except for air); *i.e.*, sound absorption is not linear with regard to frequency. As a result, the reverberation time *vs* frequency of a given room is not a straight line. A typical reverberation curve for an acoustically treated hall with a 300-person seating capacity, measuring 50 feet x 20 feet x 12 feet, is shown in Fig. 4. It must be noted that this curve holds true only when the auditorium is empty. Note the increased reverberation times (and lower absorption) at

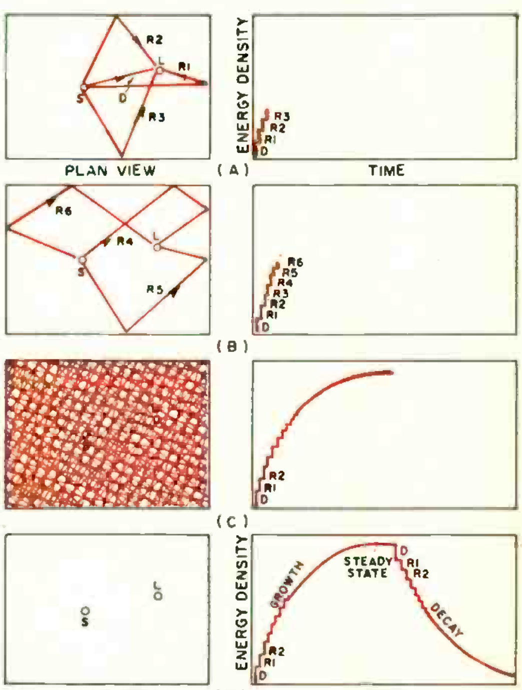
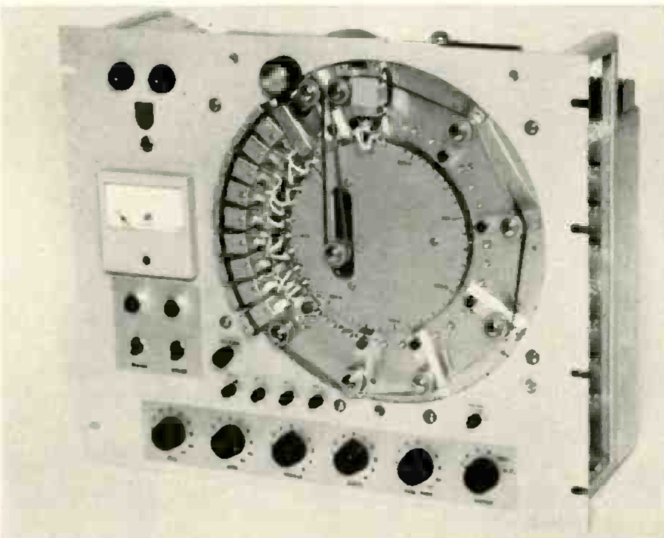


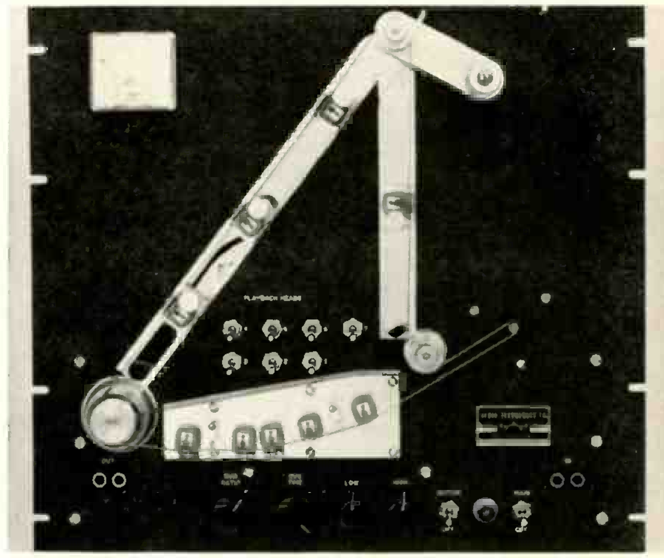
Fig. 2. The growth and the decay of sound in a typical listening room (after Olson). ▶

both extremes of the frequency range.

Fig. 2 plots a typical train of reflections in a normal room. This figure warrants some explanation; for example, a sound in a room does not build up instantly because of the finite velocity of propagation of a sound wave. This condition accounts for the initial rounded "growth" portion of the curve. The letter *D* denotes the direct unreflected first sound heard by the listener while the letter *R* denotes the reflected (echo) sounds. The acoustic energy in the direct sound (*D*) is obviously



Philips tape reverb unit shown here with front cover removed.



Audio Instrument tape reverb system uses seven playback heads.

greater than in the reflected sounds, since it is not subjected to wall absorption. The progressive reflected sounds suffer a reduction in energy at each reflection. Thus, each succeeding echo becomes smaller and smaller until all echoes have died away.

If each echo is graphed separately in time (using a logarithmic scale), a straight-line diagram such as Fig. 5A will result. This diagram is for a comparatively live room (long reverberation). Fig. 5B shows the decay of echoes in a dead room (short reverberation time).

Of special interest is the fact that the time intervals between echoes is usually in the range of two- to five-hundredths of a second in the initial portion of the echo train. Later echo pulses come in increasingly shorter time intervals. finally reaching an over-all clutter. Actually the echo density is directly proportional to the square of the elapsed time and inversely proportional to the room volume.

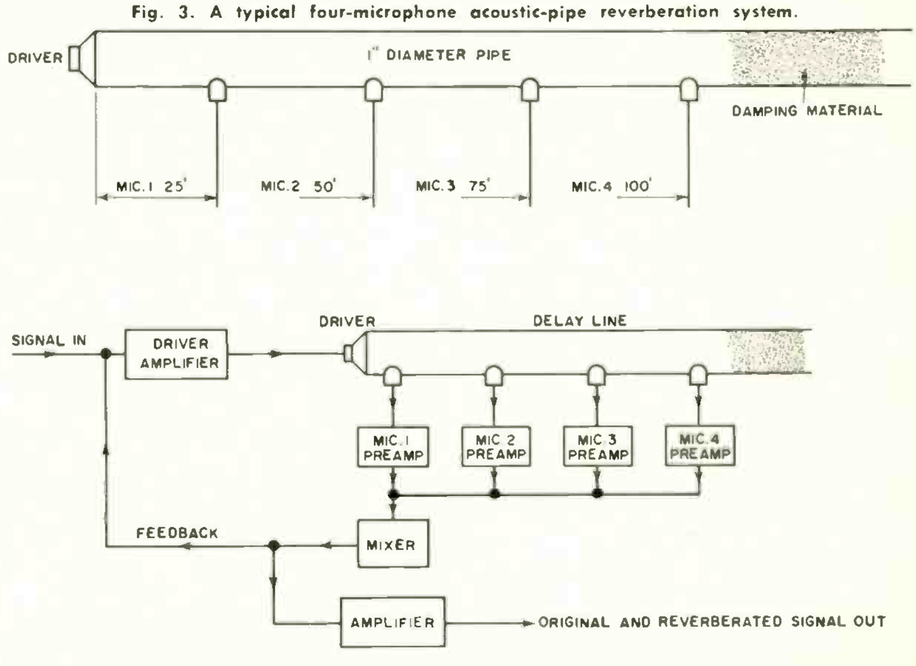
Once the returning echoes have become a clutter, the concept of individual echoes loses its meaning. The time when echoes become merged together to form a clutter is dependent upon the time duration of the original sound. For example, a sound pulse of 1-msec. duration in a room having a volume of 350,000 cubic feet will produce an echo clutter after 150 msec. have elapsed. Fig. 5 graphically shows such clutters in the final portions of the echo trains.

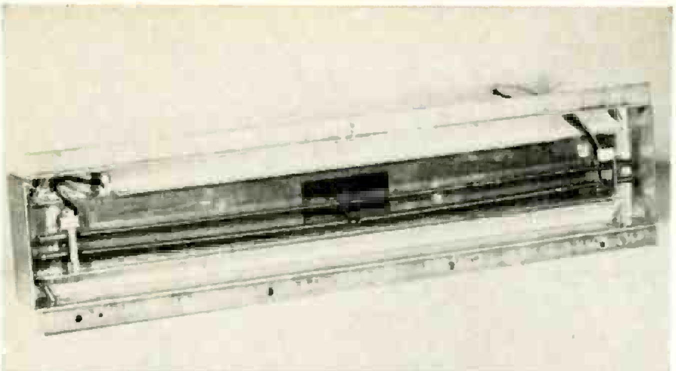
With regard to reverberation, another analogy will come in very handy. It is known that when a transmission line carrying radio-frequency power is not properly terminated in its characteristic impedance, wave reflections will occur and the energy will go up and down the line. These reflections would oscillate back and forth indefinitely if it were not for losses encountered in the line and in the line termination. Consequently, these unwanted reflections can be reduced by dissipating their energy in some form of electrical resistance located at the end of the line. In addition, every transmission line with reflections has standing waves of energy that are set up along its entire length.

This condition of reflections and standing waves is equally true in audio. For example, everyone is familiar with the hollow sound of voices in a tunnel or possibly in a long, structurally uniform hallway. This hollow sound is due to internal resonance and periodic reflections which form easily in this type of structure. As the structural nature of the enclosure becomes more complex, it becomes increasingly difficult to determine discrete resonance points and a condition is finally reached when standing waves and reflections become so random that their analysis is virtually impossible.

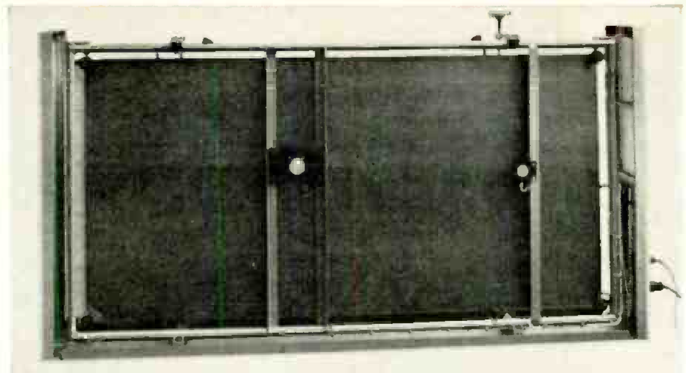
An enclosure of this type would be considered very diffuse. For example, a fairly large room with asymmetrical walls, numerous asymmetrical sound-absorbing objects, filled with people, does not really have discrete resonance points or wave reinforcements and attenuation which can be clearly determined. In such rooms (some living rooms and certain acoustically excellent auditoriums may fall into this category), all modes of sound propagation have the same or nearly the same reverberation time and consequently decay at equal rates. In addition, such enclosures are free from the unwanted flutters and echoes — in other words, periodic signal trains — which bounce back and forth between hard, symmetrical walls of the kind encountered in

Fig. 3. A typical four-microphone acoustic-pipe reverberation system.





Hammond rotational-drive dual-spring reverberation assembly. This is the device widely used in home-type reverb units.



The EMT reverberation plate showing the driving transducer at the left and the pickup microphone mounted at the right.

essentially uniform structures such as tunnels, hallways, and tubes.

Up to now we have limited our discussion to what takes place in a three-dimensional room where a sound is emitted. We have attempted to show those characteristics which make for the unique and desirable characteristics which we are all used to in our normal listening. Let us see what happens when these parameters are produced synthetically.

Artificial Reverberation

If a room has too much reverberation, sound overlapping will result and speech may actually become unintelligible. On the other hand, a comparatively long reverberation time is usually called for in music, since the prolongation and blending of musical tones due to reverberation give us a considerable degree of acoustic pleasure. Consequently, there is no single optimum reverberation time for every conceivable sound. Each sound source has its own individual optimum reverberation time which may be quite different from the degree of reverberation required by another sound.

Although there is no single optimum reverberation time, we know that when we listen to a live concert we generally do so in a large auditorium with a comparatively long reverberation time, usually on the order of one second or more. On the other hand, when we play back this music on records in our living room, we are doing it in an environment having a reverberation time of .5 second or less. Obviously, a very important tonal characteristic of the initial performance has been lost.

Over the past twenty years, a number of artificial devices have been developed to restore the original concert hall reverberation to home playback systems. As a matter of fact, broadcast studios have been using synthetic reverberators quite widely for many years. However, because of their complexity and expense, they have never enjoyed wide acceptance in the high-fidelity field. Recently synthetic rever-

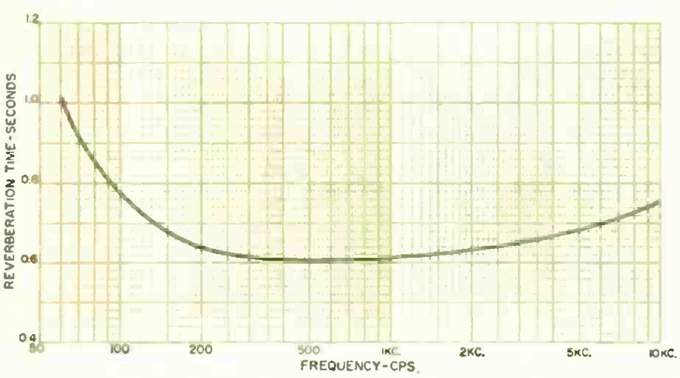


Fig. 4. Reverberation versus frequency measured in an acoustically treated hall having dimensions of 50 by 20 by 12 feet.

Fig. 5. Direct (D) and reflected (R) sounds that occur in a (A) live and (B) fairly dead room. Note that the normally exponential decay of the reflected sounds appears here as a straight line as the result of the logarithmic time scale used.

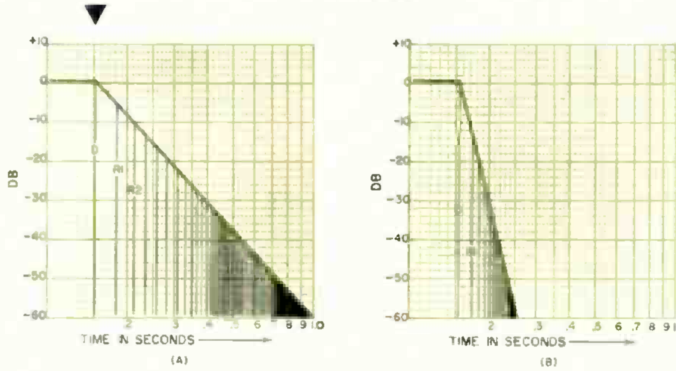


Fig. 6. The theoretical transmission loss of acoustic energy that would occur through 1-inch pipes having various lengths.

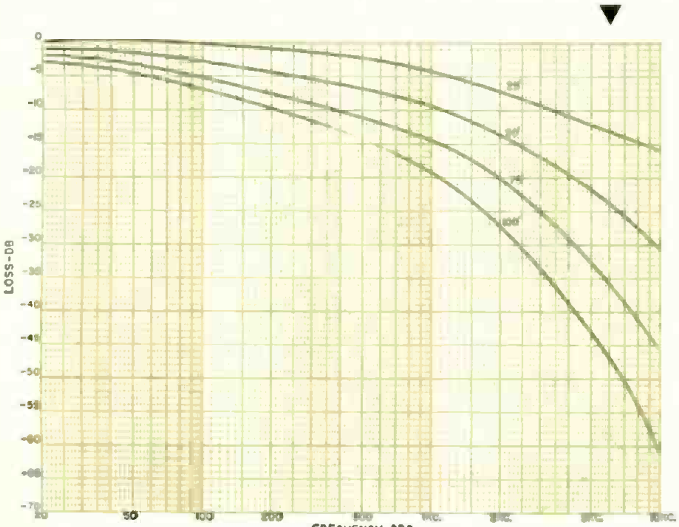
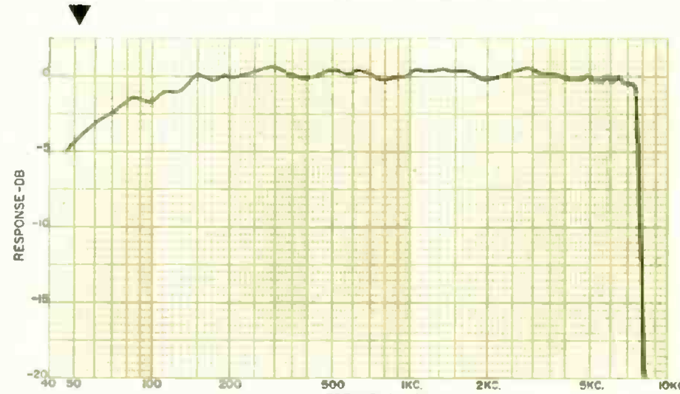


Fig. 7. Audio response of a 100-foot acoustic delay line that employs four microphones along with a feedback circuit.



beration for home music systems has staged a comeback, primarily due to some advances in the technology.

Basically, all synthetic reverberation devices can be divided into five classes: (1) acoustic delay chambers; (2) electronic delay lines; (3) acoustic pipe delay lines; (4) magnetic tape delay systems; and (5) mechanical delay systems (that may utilize metallic plates, wires, rods, and one or more springs).

Acoustic Delay Chambers. The acoustic delay chamber is unquestionably the simplest and, in some ways, the most effective method of achieving artificial reverberation. An acoustic delay chamber consists of an enclosure or room, usually quite live and varying in size (from 20 cubic feet to as much as 2500 cubic feet), in which a speaker and a microphone are placed at opposite ends of the room. The speaker emits a sound, which is reverberated by bouncing around the room in a normal manner and then picked up by the microphone. This reverberated sound is then electrically mixed with the un-reverberated signal. This technique duplicates, in a limited way, the conditions in a large hall but has the drawback of requiring a sizable soundproof enclosure, usually beyond the means of the home listener.

Electronic Delay Lines. Artificial reverberation can also be produced by sending the audio signal through a network of resistors, capacitors, and inductors in conjunction with elaborate feedback circuits. This technique, although actually possible, introduces enormous electrical losses and requires considerable amounts of equipment to achieve the comparatively lengthy delays required.

A number of such purely passive delay lines have been built, for example, at *Bell Telephone Laboratories,* utilizing standard time-constant formulas in evolving the parameters for the delay network. These systems exhibit some very favorable characteristics but their complexity places them beyond the means of the high-fidelity enthusiast.

Pipe Delay Lines. The acoustic pipe delay line has been built and used quite widely. As a matter of fact, as early as 1956, *Radio Craftsmen* of Chicago introduced a pipe delay system called the "Xophonic" to the home high-fidelity market but somehow it never really caught on.

A typical acoustic pipe-line delay is shown in Fig. 3. The system consists of a sound transducer, usually a standard driver as used in horn-type public-address speakers. This driver is acoustically coupled to a section of 1" diameter (or larger) pipe which can be anywhere from 25 to as much as 100 feet or more long. The transmission speed of sound in air is approximately 1100 feet per second. Thus, the distance covered by a sound wave in 1/20th of a second is about 50 feet. Consequently, if a microphone were located at the end of such a 50-foot tube, an acoustic delay of 1/20th of a second could be achieved. This, of course, would result in only *one* distinct delay. By placing microphones at the 25-foot point, the 75-foot point, and the 100-foot point in addition to the 50-foot point, three additional delays could be developed.

There is, of course, a practical limit to the number of microphones—in other words the number of distinct delays—which such a system could utilize. In addition, the high-frequency response deteriorates tremendously when the length of pipe increases, as shown in Fig. 6. Thus, the number of distinct delays possible in such a system is limited, being dependent upon the number of microphones inserted into the system. This condition is quite the reverse from what occurs in a room where there are, to all intents and purposes, an infinite number of separate, distinct delays.

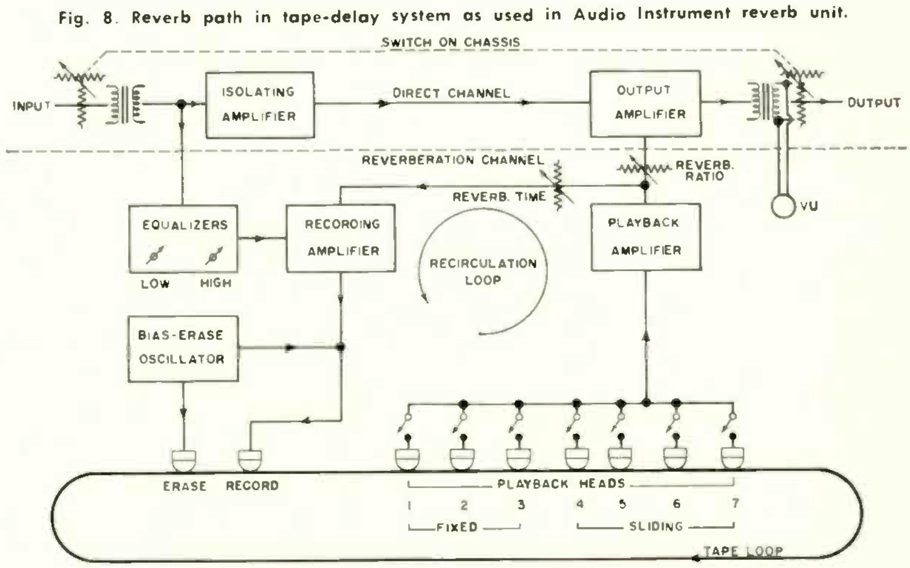
(*Continued on page* 84)

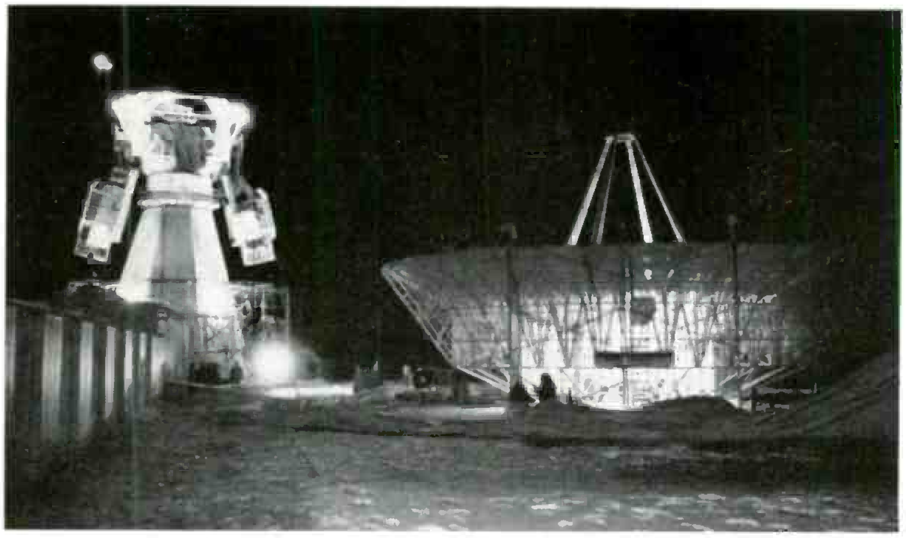
COMPANY	MODEL NO.	APPROX. PRICE	TYPE	COMMENTS
PROFESSIONAL & COMMERCIAL UNITS				
Audio Instrument Co.	44A	$1485.00	Re-entrant tape	Seven separately energized playback heads; reverb time up to 5 sec.; response 200-8000 cps ± 1 db.
EMT Co. (Dist. by Electronic Applications, Stamford, Conn.)	EMT-140	$1900.00	Plate with transverse drive	Response 50-10,000 cps; reverb up to 5 sec.
North American Philips	EL-6911	$2000.00	Re-entrant tape	Up to 8 playback heads with reverb of 8-10 sec.; response 300-10,000 cps ± 1 db.
Westrex	1400	$6350.00	Re-entrant tape	Eight separate playback heads; reverb time up to 2½ sec.; tape speed 10 i.p.s.
HOME-ENTERTAINMENT UNITS*				
Fisher	K-10	$69.50	Hammond spring; rotational drive	Reverberation up to 2 sec.; self-powered amplifier included.
Heath	GD61	$69.95	Hammond spring; rotational drive	Reverberation up to 2 sec.; kit; includes own 8-watt power amp., 8" speaker, and cabinet.
Knight	KN702	$49.95	Hammond spring; rotational drive	Reverberation up to 2 sec.; self-powered amplifier included.
Lafayette	SK-204	$69.95	Spring drive	Sound delay 1/30th sec.; includes 3-watt power amplifier, 8" speaker, and cabinet.
Utah	RVB-1	$89.95	Hammond spring; rotational drive	Self-contained speaker and amplifier.

*Does not include reverb devices, mainly Hammond type, included in packaged systems such as G-E, Motorola, Philco, Zenith, Blaupunkt, etc.

Table 1. Listing of some of the reverberation devices that are currently available.

Fig. 8. Reverb path in tape-delay system as used in Audio Instrument reverb unit.





1.

"ADVENT" SPACE ANTENNA INSTALLED

Step 1. *The nine-ton "Advent" antenna reflector is shown resting on the ground prior to its being hoisted atop its three-story pedestal shown at left in this photo.* Step 2. *The 60-foot reflector is being hoisted into place by means of 200-foot heavy-duty construction-type cranes.* Step 3. *The cranes have just been removed from the giant reflector which is resting securely in place on pedestal.*

Highly accurate Project "Advent" parabola is to be used for military communications via 3 "stationary" satellites.

WHAT is believed to be the world's most accurate space communications antenna has been installed at the Project "Advent" ground station at Fort Dix, New Jersey. This represents the first step in the development of a military communications system that will use three "stationary" active-repeater satellites above the earth. By orbiting these satellites at a distance of 22,300 miles, they will be travelling at such a speed as to keep in step with the rotation of the earth. Hence, they will appear to hang in space motionless. By using three such satellites, it will be possible to communicate between any two points on earth. This is true since at least one of the satellites would always be in view of the antennas for receiving and retransmitting a signal between two locations.

Project "Advent" is a military research and development project managed by the Army. Prime contractor for antenna development and construction is *Sylvania Electric Products Inc.*

Stability is extremely important in the design of the antenna. The aim of the 60-foot reflector must be accurate to within 0.024 degree. An antenna aiming error of only one degree would miss a 22,300-mile-high satellite by 385 miles.

To help achieve such pin-point accuracy an 84-foot hole was dug 30 feet deep at the Fort Dix site, and packed with layers of special concrete—over 5000 tons of it. On this base was constructed the 65-foot tower, weighing 190 tons, and made from 1-inch steel plate held together with 3 tons of welding rod. Workers then emplaced the rotation-elevation pedestal mount upon which the dish rests. The extremely fine meshing of the pedestal gears liken it to a precise 120,000-pound watch. Like the second hand of a watch, it can make one revolution every 60 seconds in spite of its extreme weight.

In addition to the antenna installed at Fort Dix, a similar installation is being made at Camp Roberts, California. These antennas are designed primarily for space communications in the super-high frequency range (3000 to 30,000 mc.). They will operate with the "Advent" satellites for transmission and reception of information at very high data rates. In addition, the antennas will be able to automatically track satellites using both ultra-high and very-high frequencies. Telemetry will be received from the satellites, and commands will be transmitted as well.

Initial tests in 1962 will be conducted with an active communication satellite in a 6000-mile high circular orbit with a period of approximately six hours, boosted by an Atlas-Agena B rocket. In this phase the power supply, attitude control, tracking, telemetry, command system, orbital control, and communications tests will be performed. Later launch will place "Advent" satellites in a 22,300-mile "stationary" orbit. Ultimately, Project "Advent" will prove the feasibility of such a system for instantaneous global communications through space to meet modern military needs. ▲

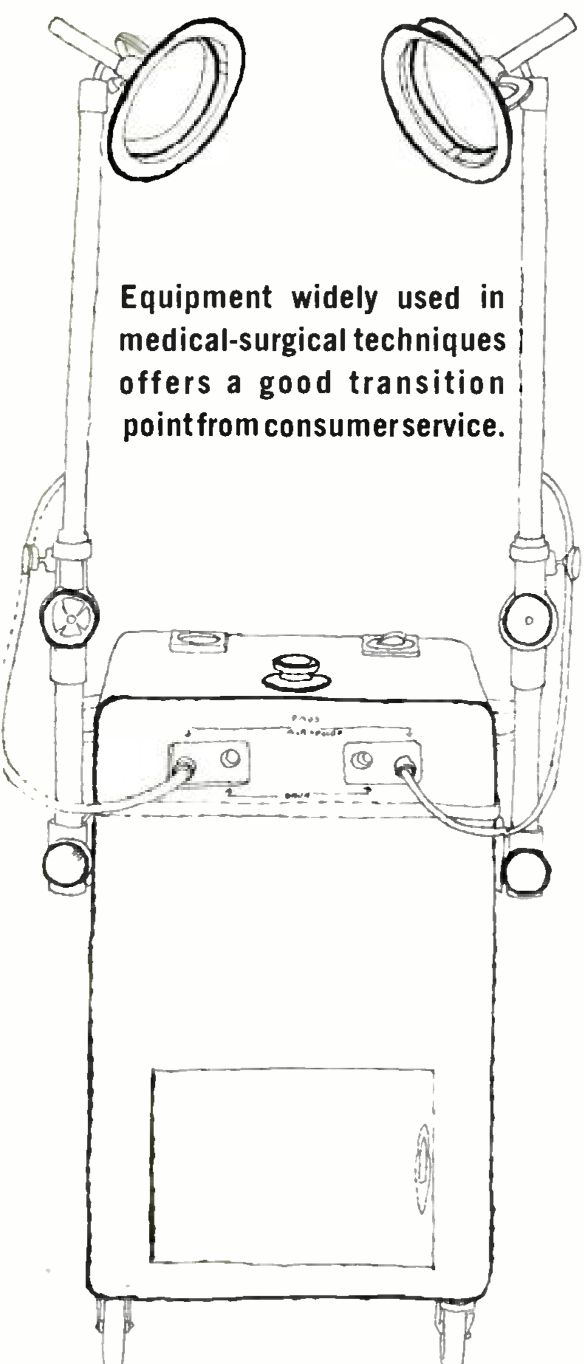
2.

3.

SERVICING DIATHERMY APPARATUS

By JOHN R. COLLINS

Equipment widely used in medical-surgical techniques offers a good transition point from consumer service.



RADIO and television technicians who are interested in breaking into industrial electronics will find the maintenance and servicing of diathermy apparatus a good place to start. Diathermy apparatus is commonly found in doctors' offices, clinics, and hospitals throughout the country. The circuits are not difficult to understand, and they can be checked with test equipment normally found in a radio or TV repair shop. While the volume of work is not likely to reach the level of TV repair, diathermy servicing can become a profitable sideline that may lead to further work in medical and industrial electronics.

Diathermy, from its Greek roots, means *through-heating,* a descriptive term since its primary function is to warm areas far beneath the surface of the skin. Heat lamps and hot water bottles cause dilation of the blood capillaries, increased circulation, and perspiration—all of which tend to disperse the applied heat. It is difficult to penetrate much beyond the surface with such devices without overheating the skin. Diathermy machines, such as pictured in Fig. 1, overcome the difficulty by providing a source of penetrating heat for inaccessible areas.

How Diathermy Works

If even a modest direct current or 60-cycle alternating current is passed through a part of the body, a painful shock will be felt. If the frequency is increased sufficiently, however, there is no sensation of shock, but only—after a period—a feeling of pleasant warmth. Even comparatively large high-frequency currents can be tolerated. A demonstration is sometimes performed to show that enough r.f. current to light a lamp held in the hand can be endured without pain or discomfort.

The reason that an r.f. current produces no harmful effects can be traced to the absence of *electrolysis*—the process by which compounds are decomposed by an electric current. Direct current and low-frequency a.c. produce actual movement of ionized particles toward the charged electrodes; this can cause both pain and destruction of living tissue. High-frequency current reverses direction so rapidly, however, that there is no tendency for ionization in the tissues to be displaced.

The warmth produced by r.f. diathermy current is the result of I^2R dissipation in the body tissue. It is maximum along the shortest path between the electrodes and in tissues having the highest electrical resistance. Fatty tissues have higher resistance than lean tissues, and both have greater resistance than bone.

The frequencies most commonly encountered in diathermy apparatus are 13.56 and 27.12 mc. Units operating at 2450 mc., however, are manufactured by the *Raytheon Company.*

In operation, it is usually unnecessary for the electrodes of a diathermy machine to be in actual electrical contact with the skin. They are normally made of flexible metal and are enclosed in insulating rubber sheets. Toweling and sometimes tissue paper are interposed between the rubber pads and the skin to help absorb perspiration.

Electrosurgery can be performed with diathermy apparatus through the use of special electrodes. The scalpel or needle is terminated in a fine point, which permits an intense concentration of current under the small area of the active electrode. It is held close to or in actual contact with the flesh. While the electrode itself remains cold at all times, the concentration of heat beneath it instantly coagulates the albumin of the tissues.

Warts and malignant growths are often removed through electrosurgery. Because bleeding is kept to a minimum, there is less chance of spreading malignant cells than with conventional surgery. Similar electrodes are used for *electrocoagulation,* in which bleeding is stopped by searing the capillaries, and *electrodessication,* whereby moisture is removed from growths.

In electrosurgery, the circuit is completed through a dispersive electrode, which consists of a fairly large metal plate in good contact with the skin, usually at a distance from the cutting electrode. The patient may sit on the dispersive electrode or it can be bandaged to the arm. While the same total current passes through the dispersive electrode as the active electrode, it is distributed over a wider area at the former and hence does not cause undue heating.

Oscillator Circuits

The heart of all diathermy apparatus is, of course, an oscillator circuit to produce high-frequency energy. While individual models differ in certain respects, it is usually possible to identify an unfamiliar unit as falling into one of the classes described below.

The principal circuit elements of the "Bandmaster" unit made by the *Birtcher Corporation* are shown in Fig. 3. A type 807 tube, connected in a conventional Miller crystal-controlled arrangement, is used as the oscillator. A small amount of r.f. energy from the plate circuit is fed back to the grid circuit through the interelectrode capacitance of the tube. The crystal, which oscillates at a frequency determined by its physical characteristics, controls the operating frequency of the circuit.

The crystal frequency in this instance is 6780 kc. The plate load, however, is a parallel resonant circuit composed of a coil and an adjustable capacitor, which is tuned to 13.56 mc. The output frequency is, therefore, the second harmonic of the crystal frequency.

Since a type 807 tube does not deliver enough power for diathermy, it is necessary to employ an amplifier circuit to obtain the needed power. A low-*mu* triode type 311CH is used, connected as a class C r.f. power amplifier. The load is a tuned tank circuit.

Triode tubes connected in this manner have a tendency to break into oscillation, owing to the coupling of energy

◀ Fig. 1. A modern diathermy machine for general use made by Dallons Laboratories, Inc.

from the plate circuit into the grid circuit. The r.f. choke in the grid circuit helps to overcome this problem. However, energy is also introduced into the grid circuit through the grid-plate capacitance of the tube, a situation that the choke does not improve. To combat this difficulty, a neutralizing capacitor is inserted in the circuit, as shown. It is adjusted to pass just the right amount of r.f. current of the proper phase to neutralize exactly the transfer of energy between the output and input circuits by way of the interelectrode capacitance.

The grid-leak resistance is made up of a 1000-ohm and a 5000-ohm resistor connected in series. For simplicity, a single resistor is shown in Fig. 3. The 1000-ohm resistor provides extra stability during standby operation. When the unit is in actual use and grid current begins to flow, however, a relay closes and bypasses this resistor.

The r.f. energy is transferred to the output circuit by means of a tapped coil, inductively coupled to the coil of the tank circuit. The output can be increased or decreased by orienting the coil to change the magnetic coupling. One part of the coil is used for diathermy, with the electrodes connected between terminals *1* and *2*. Both sections are needed for surgery: the electrodes are then connected between terminals *1* and *3*.

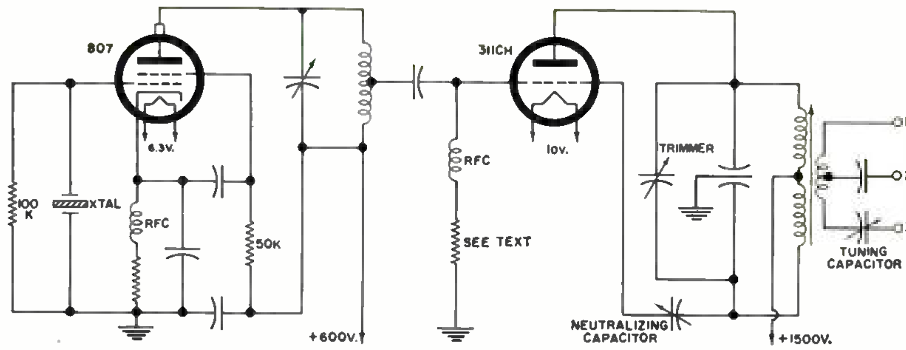


Fig. 3. R.f. oscillator and output circuitry in Birtcher's Model 800, the "Bandmaster." Different output taps are used for heating and for electrosurgery.

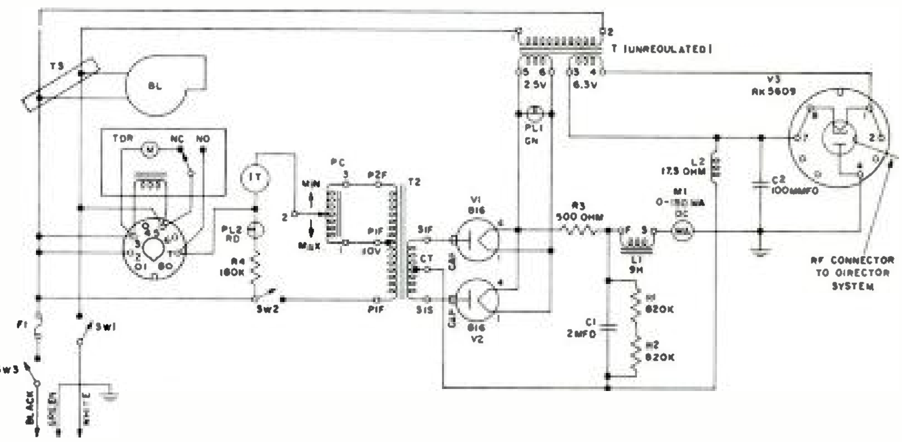


Fig. 4. Raytheon's diathermy equipment is designed to operate in the microwave range. A typical circuit, using a magnetron power oscillator, is shown here.

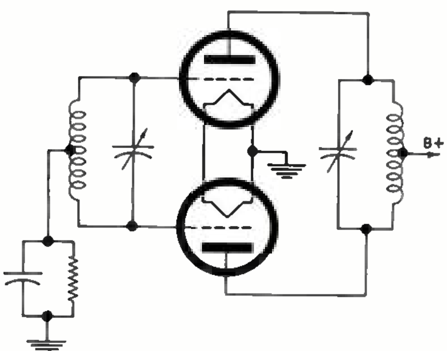


Fig. 2. Direct output of this push-pull power oscillator needs no amplification.

The tuning capacitor in the output circuit can be adjusted to match the impedance of the "patient" circuit to the impedance of the tank circuit.

Many diathermy units employ two powerful oscillator tubes connected in push-pull to supply the needed power directly without further amplification, as shown in Fig. 2. This circuit is a tuned-grid, tuned-plate oscillator. It is symmetrical with respect to ground and, since the interelectrode capacitances of the tubes are in series, the total interelectrode capacitance is only half as great as if a single tube were used. This makes the circuit especially useful at high frequencies.

Although this oscillator is not crystal-controlled, a high degree of stability is achieved through careful engineering and construction. The "Meditherm" unit made by *Dallons Laboratories* (Fig. 1) employs a similar circuit using two FV-20 or 8000 triode tubes.

A magnetron oscillator furnishes the power for the *Raytheon* microwave unit shown in Fig. 4. Since it does not depend on external tuned circuits for its operation, the unit is unlike any of the others already described. The magnetron has no grid; hence there is no transfer of power from plate circuit to grid circuit.

A variable-voltage transformer is connected across half of the primary of the power transformer T_2, permitting the output voltage of rectifiers V_1 and V_2 to be varied over a range from 1000 to about 1500 volts. Anode current begins to flow in the magnetron, V_3, when the voltage nears 1100 volts. A further increase in the setting of the variable transformer produces a greater d.c. voltage across the magnetron and, ultimately, an increase in the amount of heat delivered to the patient.

The magnetron generates high-frequency current at approximately 2450 mc., the frequency being determined by the cavity construction of the tube. The electrons from the cathode are made to travel in a circular path by the field of a strong permanent magnet. When the velocity of the electrons becomes great enough, the cavities begin to resonate and generate r.f. energy. This energy is picked up on a coupling loop and carried out of the magnetron on the center conductor of a coaxial lead which passes through a glass seal. It is then transmitted over a coaxial cable to a radiator, called a *director*, which is a bowl-shaped metal reflector resembling the reflectors used with heat lamps. The director serves to concentrate the microwave energy on the desired application area.

Power Supplies

The current requirements for diathermy equipment are quite high. It is usual to employ two mercury vapor rectifier tubes, such as types 816, 866, or 966, connected in a full-wave circuit to furnish the power needed for the unit. In the case of the *Birtcher* unit (Fig. 3), the power for the oscillator is supplied by a single type 5R4GY rectifier, while the amplifier power is furnished by two type 966 tubes.

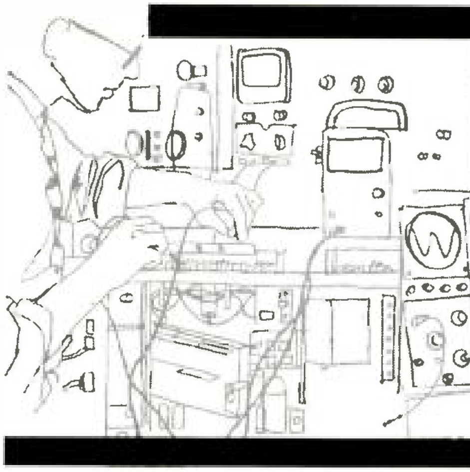
Filament transformers are usually separate from the plate transformers, as in radio transmitters. (See *T* in Fig. 4.) It is also customary to meter the power supply. This simplifies the job of servicing, since improper operation of the diathermy unit is often associated with the weakening or failure of a rectifier tube.

Servicing

When the operation of a diathermy unit is understood, the actual servicing usually presents few difficulties. Many troubles can be spotted immediately without an elaborate check.

Blower motors (see *BL* in Fig. 4) are usually connected directly across the line, and their failure can be detected by the absence of their noise and of the air from the outlet grille. Failure may indicate simply a blown fuse, in which case the rest of the unit will not operate. However, if the trouble is in the blower motor, the diathermy unit should not be operated until the former is again func-

(*Continued on page* 77)



MAC'S ELECTRONICS SERVICE

By JOHN T. FRYE

TUBE TALK

"WHAT ON earth are you doing with that ten-year-old copy of *Radio's Master?*" Mac asked his assistant, Barney.

"I'm checking on what happened to tube prices in the last ten years," Barney explained. "I just had an embarrassing experience."

"This I've got to hear," Mac exclaimed, perching himself on a stool. "I've always figured you were about as embarrassment-proof as the proverbial brass monkey. Sound off."

"Well, while you were out to lunch, this little old lady brought in a small wooden-cased radio that obviously had received tender loving care. A 14A7 was out; so I put in a new one and it played perfectly a few minutes and then began to distort. The 50A5 was one of those in which the grid goes positive and the plate current starts to creep upward as the tube gets hot. When I checked the list price sheet and told the lady a new 14A7 would cost $5.90 and a new 50A5 would be $6.25, I thought she was going to faint. She said she had never paid more than $2.50 for a tube in her whole life. Of course she admitted it had been some time since she bought any new tubes, but I was just checking to see if she could be telling the truth."

"Well, could she?"

"She not only could; she was. Ten years ago you could buy either a 14A7 or a 50A5 in standard brands for exactly $2.20."

"I hope you mentioned all prices have gone up during that time."

"I did—and more about that later. I also showed her identical list prices on the tubes from different manufacturers, but she still didn't buy."

"Why not?"

"Well, she looked me squarely in the eye and asked: 'Young man, would *you* pay $12.15 for two tubes to put into a radio that only cost $20 new?'"

"And—?"

"I simply couldn't say, 'Yes.' Quite likely some of the other tubes will be going before long, and she might easily put out twenty or thirty dollars for tubes inside a few months. I explained more modern tubes cost less and that she would be better off to put her money into a new radio, even though there wasn't a thing wrong with the old one except those two bad tubes. She thanked me, picked up the radio, and left. You mad at me?"

"Of course not. You listened to your conscience, and you'll never get any criticism from me for doing that. At least you apparently retained her good will with your honesty."

"What bugs me," Barney grumbled, "is having to explain why tubes get so expensive when they grow a little out of date—especially when I'm not sure myself. Tube pricing is one place where the law of supply and demand operates a little queerly. Apparently the less demand there is for a tube the more it costs. We both know a 14A7, a 12SA7, and a 12BE6 are basically the same kind of tube with different envelopes and bases. By the same token, a 50A5, a 50L6, and a 50C5 are blood brothers. But look what happened to their prices: ten years ago a 12SA7 cost $1.65 and a 50L6 $1.80. Now they cost $3.90 and $2.55 respectively. Ten years ago a 12BE6 cost $1.80 and a 50C5 $2.00. Now they cost $1.75 and $2.15 respectively. Don't look now, amigo, but that blows a big hole in our argument all prices have gone up in the past ten years. The price of the 12BE6 fell off a nickel. The length of time a tube type has been on the market seems to have a lot more to do with its price than the complexity of its structure or the material used in it."

"I think you're right," Mac agreed. "I've quizzed tube salesmen about this, and they explained it thusly: changing a tube production line over to run a different type of tube is an expensive affair. The cost of the changeover must be charged against the tubes run off. In the case of older tubes for which there is little demand, the number produced is comparatively small, and consequently the percentage of the changeover charged against each tube is high. When popular tubes are being run, many millions are produced at a time, and the changeover cost shouldered by each tube is very small. That, they tell me, has a lot to do with the fact that the older a tube type grows the more it costs."

"Well, that may be true, but I just wish the tube manufacturers would explain all this to the customers through national advertising. I'm tired of having a customer look at me as though I were one of the James boys when I read off to him the list prices on some of those older tubes. The ones who set the prices should explain them. Until they do, lots of people are going to feel that good mottoes for tubes and tube manufacturers respectively could be taken from those two lines printed on the side of our cellophane tape dispenser."

Mac's face wrinkled into an appreciative grin as he read aloud the old Dutch lament: "We grow too soon old und too late shmart."

"You may have something there, Buster," he said indulgently; "but while we're on the subject of tubes, I want to bring up something I read in the 1961 Winter Issue of *Sylvania News*. When and why tubes fail is of deep concern to everyone connected with the manufacture, use, or maintenance of electronic equipment. Now we're in industrial electronics servicing, tube failure-rate is especially important to us, for such a failure in industrial equipment can be far more serious than a similar failure in home radio or TV sets.

"Obtaining really reliable data on tube failures is a big and expensive undertaking; but *Sylvania*—and doubtless other tube manufacturers have some sort of similar program—has been studying tube reliability in various makes and models of TV receivers under controlled conditions since 1950."

"How do they go about it?"

"First they experimented to determine what test conditions would provide the most information in the least time. They settled on operating batches of ten identical receivers for 1500 hours—the equivalent of a year's normal use—under the following conditions: The sets were operated at 130 volts a.c. They were on for 50 minutes and then off for 10 minutes for the 1500 hours except that once every twenty-four hours they were turned off for a full hour. Brightness and contrast were set for normal viewing. When a tube failed, it was replaced and the test continued. If the replacement tube also failed before the end of 1500 hours, it was not counted in the failure group; but the failure was noted as possibly indicating a critical application in *that* socket.

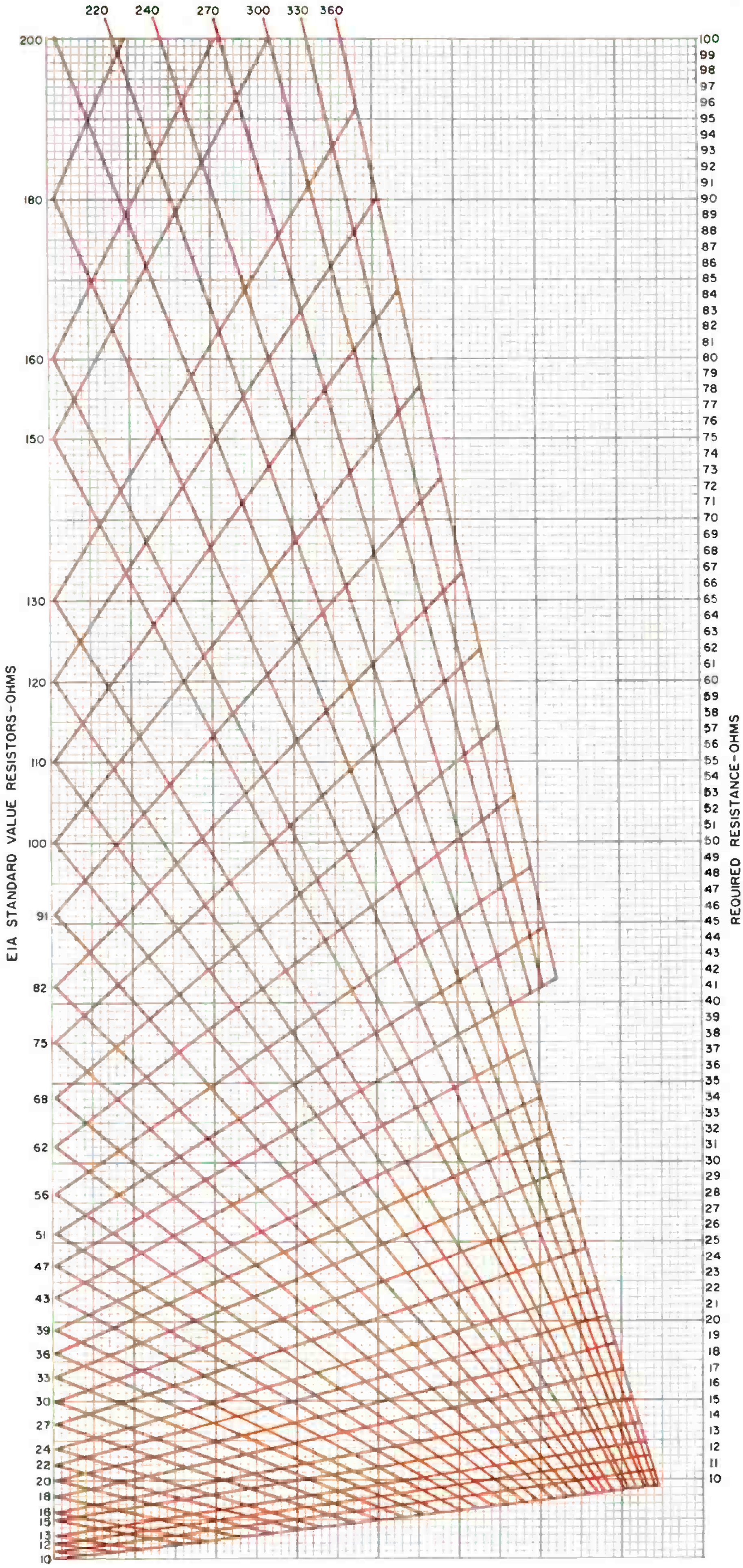
"To determine how much the boosted line voltage accelerated tube failure, ten more identical sets were operated under precisely the same conditions, except the line voltage was 117 volts; and tube failures between the two groups were compared. During the earlier years of the test program, the ratio of tube failures at 130 volts to those at 117 volts was 2.4/1; but since that time it has increased to 3.9/1. In other words, you can expect almost four times as many tube failures at the increased line voltage. This ratio check is not carried out with every batch of sets tested, but it is performed often enough so that the number of failures at normal line voltage can be predicted from those occurring at the higher voltage.

(*Continued on page* 80)

parallel resistance calculator

By **M. A. HAMMOND**

A choice of the possible pairings that make up the value desired can be read off without calculation.



ANYONE who needs to make up a resistance value from what is on hand will find this chart useful. Series pairs can be worked out with mental arithmetic. Parallel pairs, especially when a choice of possibilities is wanted, involve time-consuming calculation. The chart quickly reveals the range of pairings, in EIA values, that equal or approximate the desired resistance.

Starting with the needed value on the right-hand scale, read horizontally to the left until a point is reached where two diagonals intersect. Following each diagonal to its termination on the left reveals the two resistors required. For example, assume that 35 ohms is sought. A pair of intersecting diagonals on the 35-ohm line lead to 51 and 110 ohms.

Precision requirements and tolerance variations permit some flexibility in matching pairs. Thus other points of intersection close to the 35-ohm line yield such additional pairings as 43 and 200; 43 and 180; 47 and 130; 56 and 91; and 62 and 82. The least accurate combination is within 3 per-cent.

For values higher than those shown, add the necessary number of ciphers to the significant figure on the right; then add the same number of ciphers to each figure read on the left. Thus 350 ohms is obtained with 510 and 1100 ohms. However, only pairs in the same decade can be read. For example, parallel resistance for 330 and 330,000 ohms is not given.

Other uses: the parallel value of two known resistors is found by following their respective diagonals from the left until they intersect. It is also possible to find the value of a shunt for a given resistor to reduce it to a desired value: trace the diagonal for the given value to its intersection with the horizontal line for the desired value. Then find another diagonal that comes close to intersecting this point.

The author originally published another version of this calculator, based on preferred-value resistors used in England, in "Wireless World." This version has been adapted to EIA values and expanded. ▲

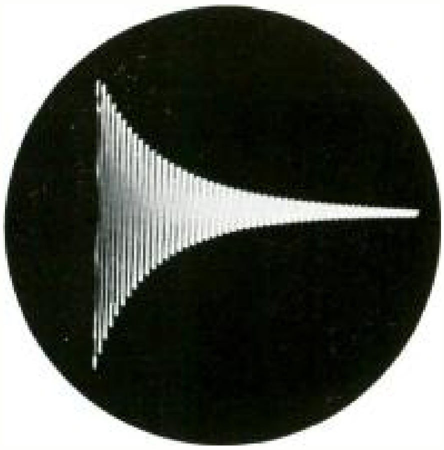


Fig. 1. Damped oscillation in flyback transformer with h.v. rectifier removed.

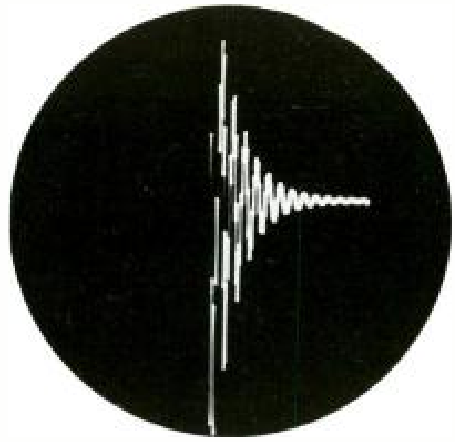


Fig. 2. H.v. rectifier restored: loading effect of its filament on flyback.

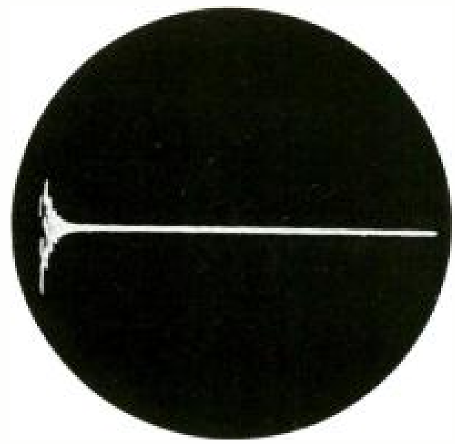


Fig. 3. Only one shorted turn in the flyback produces this excessive damping.

DYNAMIC TESTS with a SERVICE SCOPE

An intriguing but simple technique permits quick, positive tests of numerous components and circuits in TV and radio that resist the ordinary checks.

By J. B. STRAUGHN / National Radio Institute

THE TECHNIQUE presented here has a broad range of application in all types of troubleshooting, particularly in radio and TV, for testing individual components and entire circuits. In cases where other methods are available, it can provide such advantages as quicker results, greater ease, and more positive indication. Beyond this, it is well suited for certain checks where no alternate methods have proved themselves good enough to win wide acceptance.

In general, the technique involves excitation of a resonant circuit by a pulse extracted from the bench oscilloscope — and simultaneously observing the effect on that same scope. The term "resonant circuit" would seem to limit the range of tests. Normally the expression calls to mind an inductance associated with a capacitor. However, the capacitor need not be a separate component. A coil's own distributed capacitance or the stray capacitance of an associated circuit is enough to tune the inductor to some particular frequency.

The flyback transformer of a TV receiver is a good example. As shown in Fig. 7, the entire circuit is resonant due to capacitance aside from the transformer itself and also distributed capacitance C_1. If the transformer were to be removed entirely from its circuit, it would still resonate with C_1, although at a higher frequency. More readily recognizable, resonant circuits are seen in Fig. 8, a quadrature audio detector. These are C_1-L_1, the sound take-off coil, and C_2-L_2, the quadrature tank.

In ordinary radios, resonance tests can be used on such components as loop and ferrite-core antennas, oscillator tanks, i.f. transformers, and audio-output transformers. In addition, TV components and circuits such as the following can be checked: the complete horizontal-sweep circuit, the flyback transformer alone, yokes, 4.5-mc. sound coils, and such others as width, linearity, ringing, and peaking coils.

Advantages

Few situations give a service technician more pleasure than those in which he can make a reliable check, in circuit, without having to unsolder leads or components. The feasibility of doing so reliably will depend on such factors as the type of component, its value, and the associated circuit. A simple ohmmeter is enough to check a resistor in its circuit, for example, if nothing shunts the component that could falsify the reading. There are cases where a capacitor might be checked for an open condition or leakage without much trouble.

With an inductor, things are not always so easy. Take a flyback transformer or yoke. A shorted turn or two can render the part useless, but will not show up on an ohmmeter check. If you do not have a reliable inductance checker, substitution may be the only sure recourse. But, aside from being time-consuming, substitution can be expensive. A special part may have to be ordered. If its use indicates that the original component is good, you may be stuck with the replacement. The same applies, to a lesser degree, to other inductive components. If substitution involves removal from a printed board, there is twice as much to be unhappy about.

Fortunately, you can easily rig your scope to test such parts directly without substitution, often in the circuit, and quickly. Where the in-circuit method is inadvisable, direct checks can be made by removing a lead or so.

How It Works

A resonant circuit that can sustain a signal may be shock-excited by a sharp voltage pulse. When so excited, it will go into oscillation at its resonant frequency; but this oscillation will rapidly die out, producing a damped wave, as shown in Fig. 9A. Amplitude and duration of the damped waves for a given voltage pulse depend on the "Q" of the resonant circuit. If a defect were to drop "Q" below normal, the circuit would not function properly in a receiver. Also, when the circuit is shock-excited, the length of the train of damped oscillations would be sharply reduced to resemble the waveform of Fig. 9B.

The deflection volt-

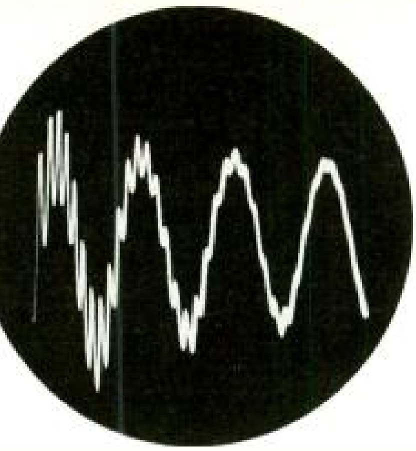


Fig. 4. Damped waveform of Fig. 3 with the scope's frequency controls re-set.

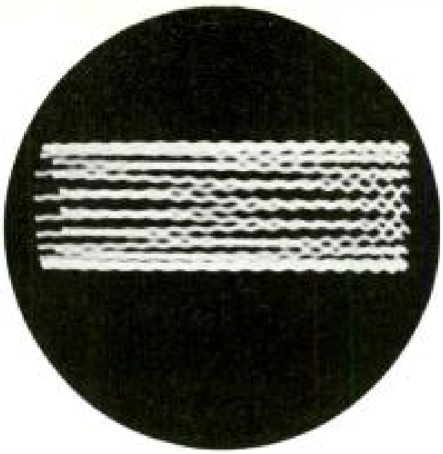


Fig. 5. A.c. pick-up due to an open condition in the inductor being tested.

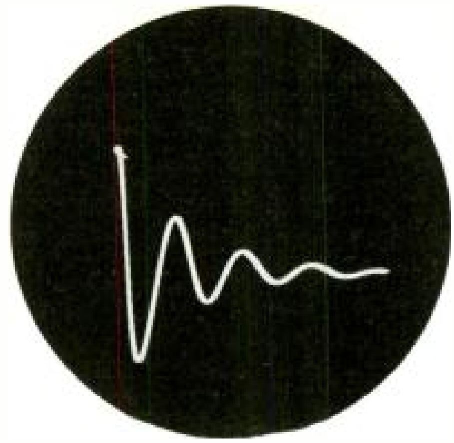
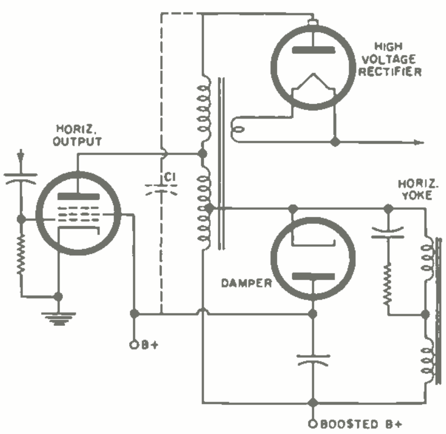


Fig. 6. Waveform normal for audio-output and other low-"Q" iron-core inductances.

age produced by the horizontal sweep generator of the oscilloscope is a saw-tooth. For rapid return of the electron beam from one side of the CR tube's screen to the other during retrace time, the saw-tooth edge is sharply vertical. To prevent a retrace line from marring the scope display, most instruments apply a blanking pulse to cut off the electron beam during the retrace interval. This sharp voltage pulse, also obtained from the sweep generator, has the same repetition rate as the scope's horizontal-sweep frequency.

Suppose we apply this blanking pulse to some external resonant circuit and also connect the vertical leads of the scope across that same circuit. The



sharp pulse, not seen itself because it occurs during retrace, will shock-excite the external circuit into damped oscillation at the frequency of resonance. Also suppose that the sweep frequency of the scope is adjusted so that, just as each damped wave train is dying out, a new blanking pulse excites the circuit into oscillation again. The damped waveforms will form a continuous display, as shown in Fig. 9A.

The appearance of the display can tell us a great deal about the condition of the resonant part or circuit. Interpretation of results and the choice of sweep-frequency settings for various components will be considered later. Important here is the fact that the set-up is practical. All that is needed is a convenient way of extracting the pulse from the scope for excitation.

There should not be much difficulty

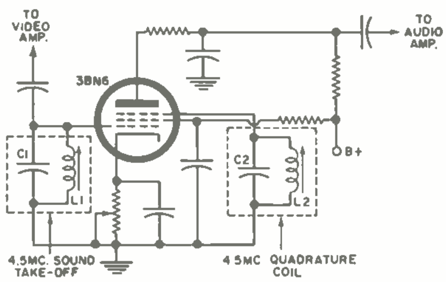


Fig. 8. Another circuit using resonated inductors: the gated-beam audio detector.

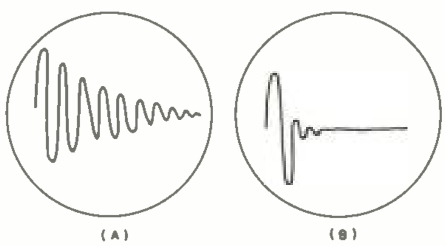


Fig. 9. Damped oscillation (A) produced in shock-excited resonant circuit. Increased damping (B) induced by a defect.

◀ Fig. 7. The flyback transformer resonates with its own wiring capacitance.

in providing external take-off of a shock-exciting pulse from any oscilloscope. It was particularly easy on the *Conar* Model 250, which the author used. This instrument has a Z-axis binding post, at the lower right in Fig. 11, originally intended for introducing an external signal to modulate the beam. This feature is so seldom used by service technicians that it was decided to use the binding post for bringing out the pulse-test voltage. Originally this post connected to the output of the blanking amplifier simply with a length of wire. Replacing this wire with a coupling capacitor of 5 to 10 $\mu\mu$f. would bring out a portion of the blanking-amplifier output to the binding post. However, a regular capacitor was not used. A gimmick capacitor was made up by twisting together the ends of two lengths of insulated hook-up wire. Three to five twists are sufficient. One free end of the gimmick was then soldered to the Z-axis post and the other free end to the output of the blanking amplifier.

To connect the scope for resonance testing, a simple piece of wire or a suitable length of solder is now connected between the former Z-axis post and the

Fig. 10. Take-off points for pulse-coupling gimmicks in six popular service scopes.

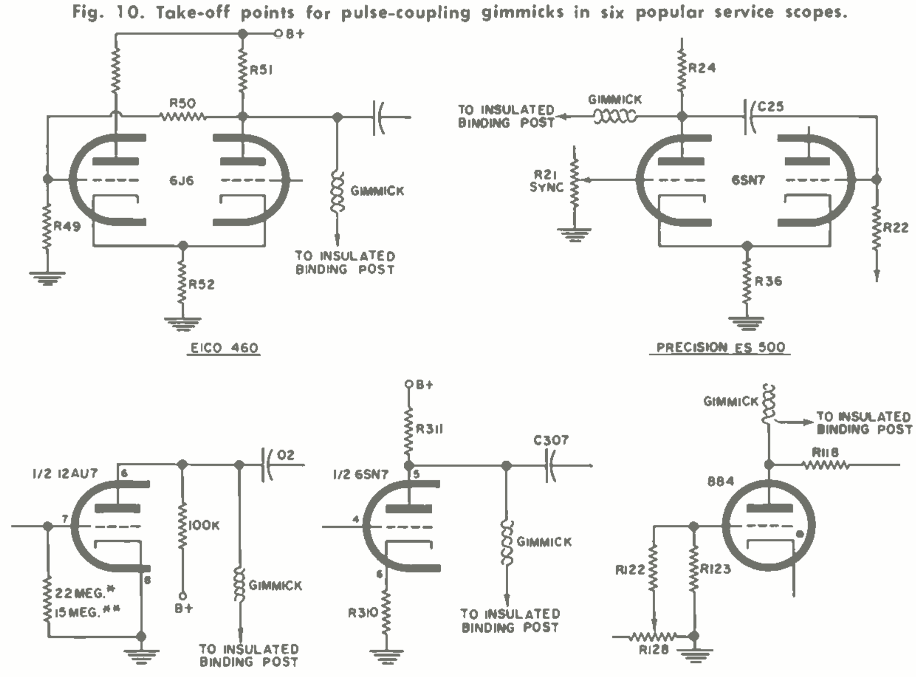


Fig. 11. Binding post for blanking output (right) is temporarily connected to vertical input (broken line), with latter connected (arrows) to external circuit.

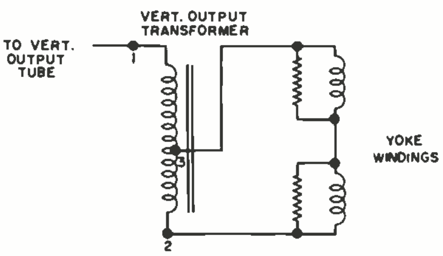


Fig. 12. Checkpoints (1, 2) in vertical-output transformer. Disconnect yoke (3).

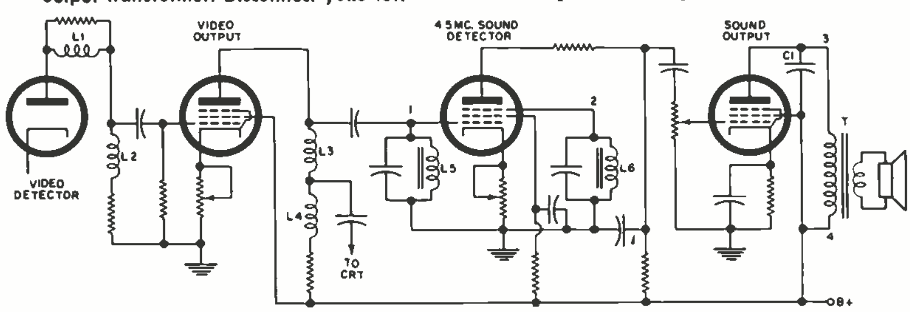


Fig. 13. All inductors shown (peaking, audio i.f., and sound-output) can be checked.

vertical-input post, as shown by the broken line in Fig. 11. With ordinary test leads, the vertical-input and ground terminals are then connected across the external circuit.

On other oscilloscopes, the arrangement may differ somewhat. In some cases, a binding post may have to be added. However, this will rarely be the case. Most instruments have more than one post on the front panel for making ground connections. One of these—the one that is farthest from the vertical-input circuit—can be employed to bring out the pulse signal. Any connection to the lug must first be removed. Then the post must be insulated from the front panel with a fiber washer or a new, insulated post must be installed.

Make up a gimmick from two lengths of insulated, hook-up wire, as already described. Check across the two free ends with an ohmmeter to make sure that no d.c. path exists. Connect one free end to the binding post selected. The other end is soldered to the plate of the blanking amplifier, if your scope uses one.

Where there is no blanking amplifier, take-off can be obtained from some point in the horizontal sweep generator's circuit. As a rule, the free end of the gimmick would go to the plate in the sweep-generator circuit that does not directly produce saw-tooth output. Various take-off points for a number of popular oscilloscopes are shown in Fig. 10. If your scope is not one of these, it may have similar circuitry. If you are not sure as to the right point, it can be determined experimentally.

Simply connect the shorting bar between your new output post and the vertical-input post; connect the scope's input leads across a suitable, resonant circuit (the oscillator tank of a radio receiver will do); make certain that no power is applied to the radio or other resonant circuit used; and turn on the scope. The scope sync control is turned off or to minimum position. The free end of the gimmick is then touched to various points in the horizontal sweep circuit until the damped-oscillation waveform appears. Some manipulation of the vertical and horizontal controls will be necessary to display the waveform properly. When the latter is obtained, the free end of the gimmick is permanently soldered to the point from which the appropriate exciting pulse was taken.

Setting Up the Test

The procedure just described is essentially the one that will be used whenever the resonance-test technique is to be used, except that there will be no need for probing to find the take-off point, which will be immediately available from the special, front-panel post. The latter will simply be connected externally to the positive vertical-input terminal, which will also be connected to one side of the component or circuit to be tested. The other side of the circuit under test will be returned to scope ground. The component under inspection will not be powered. Scope frequency controls will be adjusted to show the individual cycles of the damped wave train. The sync selector may be set to either negative or positive synchronization. If there is a control for the synchronizing voltage, use as little as possible. With most instruments, none is necessary. Vertical and horizontal gain controls are manipulated in the ordinary way to produce a display of usable proportions.

When a test is completed, the scope is restored to normal use simply by removing the shorting bar from the special pulse-output post to the vertical-input post.

As to frequency settings used, experience will, in the long run, indicate which ones are to be used for which circuits or components. Since the sweep rates marked on the coarse frequency controls of most instruments are scarcely precise, exact figures cannot be given. However Table 1 is a good general guide that can be used as a starting point. You should check the settings on your own scope against types of components and circuits that are known to be good and, if wide variations from the table are noted, you can make up your own list or alter the one shown accordingly. Once you have done so, normal settings can actually be a guide in troubleshooting. If you find that a wide deviation from the normal frequency range is required for a particular part, this is an indication of defectiveness.

Evaluating Results

Full mastery of the technique also depends on a little practice with actual circuits. There is much about the technique that can be learned from properly operating circuits before an attempt is made to apply it to defective ones. In general, the number of cycles in the damped-waveform display obtained is an indication of circuit "*Q*." The scope frequency required to produce the display is an indication of coil inductance.

How actual test results are interpreted can best be explained with specific cases. The user is advised to try out the checks discussed here to get the knack. Let us first make a check at a flyback transformer—a part of the TV set where the technique will be used often. The receiver is disconnected from the power line. The high-voltage rectifier is removed from its socket. The

(*Continued on page* 87)

Table 1. Suggested scope frequency settings for TV-radio inductors and circuits.

Receiver Part or Circuit	Sweep Rate
(TV Receiver)	
Width Coil	10-100 kc.
Horiz. Linearity Coil	10-100 kc.
Horiz. Output Transformer	1-10 kc.
Yoke (Horiz. or Vert.)	10-100 kc.
Deflection Circuit (Yoke Connected)	10-100 kc.
Deflection Circuit (Yoke Disconnected)	1-10 kc.
4.5-mc. Sound Take-off Coil	100-500 kc.
4.5-mc. Sound Quadrature Coil	100-500 kc.
(AM Receiver)	
I.f. Transformer (455-kc.)	10-100 kc.
Ferrite-core Antenna Tank	10-100 kc.
Oscillator Tank	10-100 kc.

4 CHANNEL AUDIO MIXER

By **JACK D. WILLIAMS**

Construction of portable, low-Z mike mixer for recording. Features include ease of maintenance, good performance.

DO YOU make high-quality tape recordings that require mixing several microphones? If so, this four-channel audio mixer might be just the companion piece you need for your tape recorder. This unit, built for a local recording studio, was intended for field use in conjunction with a tape recorder. For this reason, size was reduced to a minimum but no attempt was made at miniaturization. Ease of servicing and conventional circuits were emphasized. Only one tube type was used (12AY7), enabling the operator to carry only one extra tube in the trouble bag in case of tube failure.

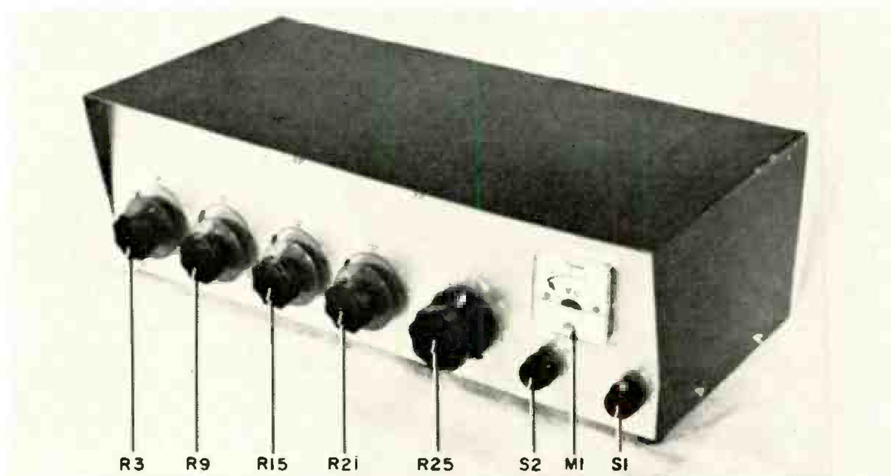
One extra feature provided by the mixer is the ability to monitor, on the vu meter, the cathode voltage of each amplifier stage. This allows the operator to know at a glance if a stage is operating near normal, and also gives a useful indication when a tube is nearing the end of its life. This feature is usually found only on broadcast equipment. Of course the meter cannot indicate noise, hum, gas, etc., so the normal maintenance routine should always be followed.

Planning

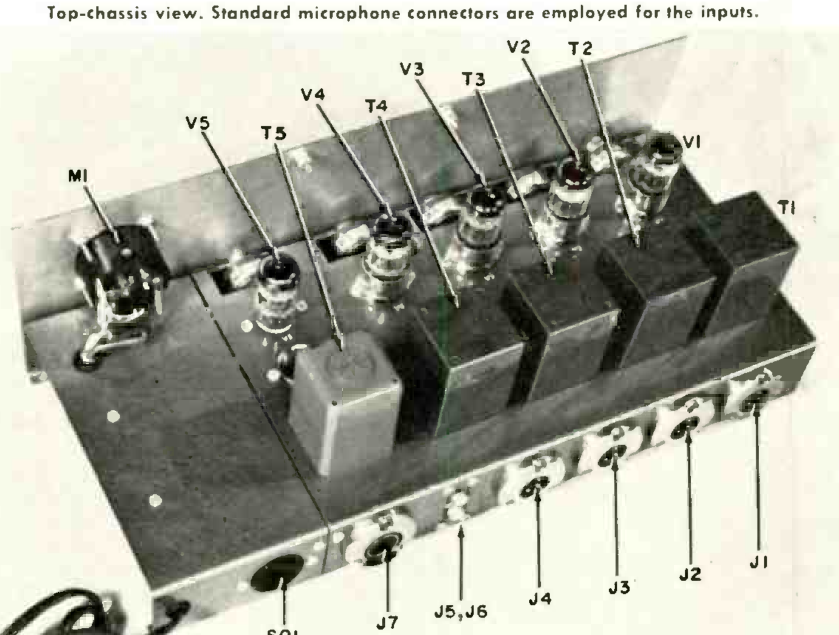
Most recorders usually have a monitor speaker which, after all, is the one logical point to monitor, since this represents the final condition of the audio being recorded. To avoid needless duplication and simplify the power output requirements, it was decided not to include a speaker in the mixer. Also, since most recorders do not require a high level to drive them, it was felt that there was no need to amplify the signal up to a +16 or +18 dbm only to pad it back down—in this case to a −26 dbm; especially since the output cable to the recorder would rarely exceed a few feet in length. Some padding would be desirable and, as the signal would usually be "bridged in" to the tape recorder, this would also provide a load irrespective of what the mixer might be feeding. This and the fact that it takes a +4 dbm to feed a standard vu meter, results in the output requirement of +4 dbm.

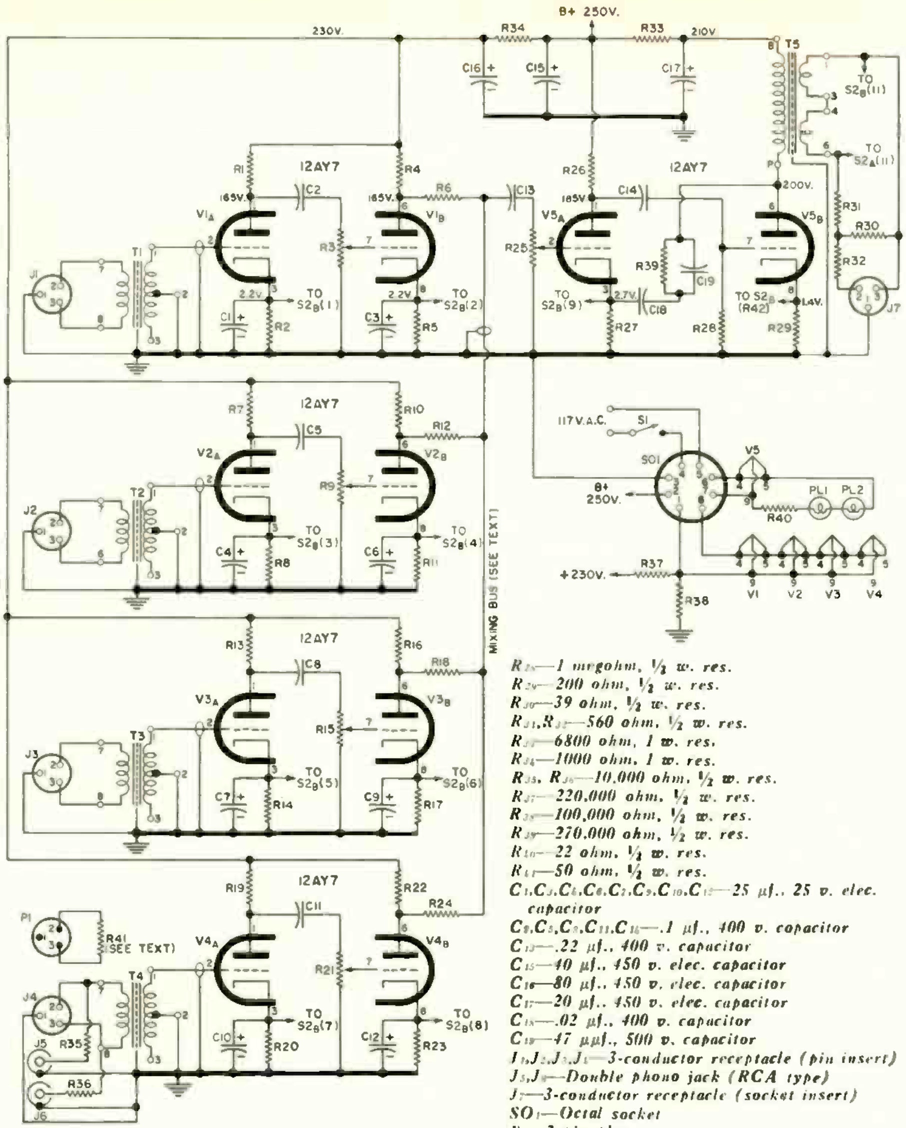
A 30-db pad then provided excellent isolation and correct level (−26 dbm) between the mixer and the recorder. This level will vary from recorder to recorder and will depend on what stage is being fed, *i.e.*, low-level microphone, high-level bridging, or regular line input. However, it will be a rare instance where more than +4 dbm will be needed. A word of advice should be inserted here. Always use the highest level input available and avoid needless reamplification of the signal. More stages can only mean added distortion.

The mixer was to be used with several makes of microphones, including bi-directional and cardioid types, which meant that the input transformers must not be loaded. This ruled out the use of the conventional transistor preamplifier in which no transformer is used and the input impedance is made to match the microphone. An input circuit of this type would prevent the correct use of



Front-panel view of the author's mixer. R_{25} is the unit's master gain control.

Top-chassis view. Standard microphone connectors are employed for the inputs.




R_{28}—1 megohm, ½ w. res.
R_{29}—200 ohm, ½ w. res.
R_{30}—39 ohm, ½ w. res.
R_{31},R_{32}—560 ohm, ½ w. res.
R_{33}—6800 ohm, 1 w. res.
R_{34}—1000 ohm, 1 w. res.
R_{35}, R_{36}—10,000 ohm, ½ w. res.
R_{37}—220,000 ohm, ½ w. res.
R_{38}—100,000 ohm, ½ w. res.
R_{39}—270,000 ohm, ½ w. res.
R_{40}—22 ohm, ½ w. res.
R_{41}—50 ohm, ½ w. res.
C_1,C_3,C_4,C_6,C_7,C_9,C_{10},C_{12}—25 µf., 25 v. elec. capacitor
C_2,C_5,C_8,C_{11},C_{14}—.1 µf., 400 v. capacitor
C_{13}—.22 µf., 400 v. capacitor
C_{15}—40 µf., 450 v. elec. capacitor
C_{16}—80 µf., 450 v. elec. capacitor
C_{17}—20 µf., 450 v. elec. capacitor
C_{18}—.02 µf., 400 v. capacitor
C_{19}—47 µµf., 500 v. capacitor
J_1,J_2,J_3,J_4—3-conductor receptacle (pin insert)
J_5,J_6—Double phono jack (RCA type)
J_7—3-conductor receptacle (socket insert)
SO_1—Octal socket
P_1—3-pin plug
P_2—Octal plug
S_1—S.p.s.t. switch
PL_1,PL_2—Meter lamp
T_1,T_2,T_3,T_4—Input trans. (ADC-24, UTC A-10, UTC A-11, see text)
T_5—Plate to 600-ohm line trans. (UTC A-25)
1—6" x 14" x 1½" chassis (see text)
V_1,V_2,V_3,V_4,V_5—12AY7 tube

R_1, R_4, R_7, R_{10}, R_{13}, R_{16}, R_{19}, R_{22}, R_{26}—27,000 ohm, 1 w. res.
R_2, R_5, R_8, R_{11}, R_{14}, R_{17}, R_{20}, R_{23}, R_{27}—1000 ohm, ½ w. res.
R_3,R_9,R_{15},R_{21},R_{25}—250,000 ohm, 2 w. audio-taper pot
R_6,R_{12},R_{18},R_{24}—5600 ohm, ½ w. res.

Fig. 1. Complete schematic diagram of mixer. Separate power supply is employed.

mass-controlled bi-directional and cardioid microphones as any loading caused by the input circuit will alter the frequency response of these microphones.

Circuit

An open-grid preamp was chosen (see Fig. 1), using the type 12AY7. This tube has very low-level hum, low microphonics, and minimal sources of internal noise. It also has a record of proven reliability in many hours of broadcast service.

The gain controls were inserted between stages in the preamp so that high-quality molded carbon potentiometers could be used. This represents a huge savings over T- or H-pad variable attenuators and also reduces the size of the controls considerably. Direct current must not be allowed to flow through the potentiometers, to insure continued noise-free operation. Therefore, only capacitors with little or no leakage must be used in these stages.

A few words on capacitors are in order here. The author and his co-worker needed a large number of high-quality, low-leakage capacitors for the rebuilding of live television camera chains. We found through extensive tests that the new dual dielectric (Mylar-paper) capacitors have almost unmeasurable leakage. The use of these Mylar-paper capacitors allows a reduction in size and cost over expensive, oil-impregnated, metal-cased capacitors—at no apparent sacrifice in performance.

The second stage (V_{1B}) is identical to the first with the exception of the mixing bus. These two stages complete the preamp and provide about 50 db of gain exclusive of the input transformer. The mixing bus used here is not unknown but is very seldom seen. It reduces the size of components to a minimum by using resistors instead of the usual capacitors and works very nicely in this application. A build-out resistor, R_6, is used for the purpose of lowering the interaction between stages. The mixing bus is made with two short lengths of RG/58U. This was chosen because it is shielded and has very low distributed capacity (28.5 µµf. per foot). This cable was also used for the grid leads from the input transformers and was attached to the ground bus at only one end. R_{25} serves as the master gain control and, like the previous controls, is a high-quality molded carbon potentiometer.

More amplification is provided by V_{5A} which also serves as a driver for the output stage V_{5B}. A 12AU7 would have been more suitable for the output but it would not provide enough gain. A 12AX7 would work nicely as a voltage amplifier but is not considered the best choice for an output stage. No literature could be found covering the use of the 12AY7 as a power amplifier, so a series of tests was made, using an experimental set-up. The parameters on the amplifier were then varied until distortion was reduced to a minimum. These values, while below the maximum plate voltage and plate current ratings of the tube, still exceeded the plate dissipation rating. A compromise would have to be made.

There still remained the application of feedback, which would serve two purposes. First of all it was needed to provide frequency compensation for the input transformers. These transformers were obtained as a surplus item and their frequency response started falling off below 100 cps. Feedback would also serve to reduce the distortion which, as in most amplifiers, occurs in the output stage. With the plate voltage and current reduced to a suitable value, feedback was taken from the plate of V_{5B} and fed to the unbypassed cathode of V_{5A}. This not only corrected the frequency response of the input transformers but also reduced the harmonic distortion to a very reasonable amount at all but the lowest frequencies (40 cps and below). By eliminating the cathode bypass capacitor on V_{5B}, enough additional feedback was obtained to reduce the remaining distortion to the final figures listed below.

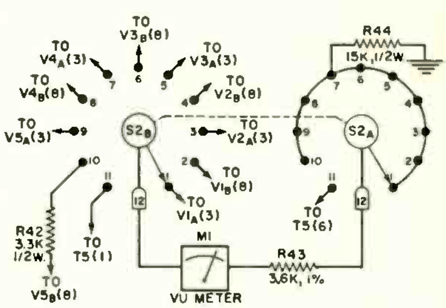


Fig. 2. Switching circuit for vu meter.

For those who may use different transformers and may want to vary the amount of feedback, R_{39} adjusts the amount of feedback at all frequencies, while C_{18} serves as a blocking capacitor and also determines the feedback of the lower frequencies. This reduction of feedback at the lower frequencies increases the gain at the low end so that the over-all gain is constant. A larger capacitor will increase feedback, and therefore reduce gain at the low frequencies. C_{19} serves to reduce a peak at the high frequency end which is also caused by the input transformers. This may be omitted if not needed.

It was decided that since the tape recorder usually employs a large and accurate vu meter, only a small and perhaps not-so-accurate vu meter would be required on the mixer. This is primarily needed to insure adequate signal-to-noise ratio and to reduce the

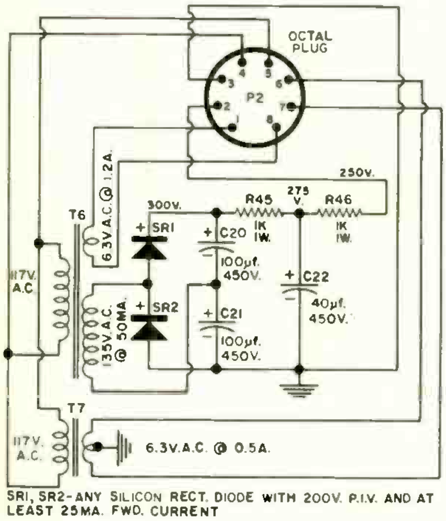


Fig. 3. Circuit of separate power supply.

possibility of overdriving the input to the tape recorder.

A small, imported unit was ordered but because of its small size (1⅝ inches square) and low price, there was some understandable doubt as to its usefulness. We were pleasantly surprised to find that it was quite accurate on frequency response and with program material appeared to be damped much like professional vu meters. Its small size was not really a handicap, although a larger meter would be preferable in the studio.

As mentioned earlier, in addition to monitoring the program material, the meter is connected to the cathode of each amplifier stage by a 12-position switch (the 12th position being "off"). See Fig. 2. This allows the operator to check the operation of each stage by simply rotating the switch. A word of caution: This should be done before recording to prevent any switching noise in the program material.

When the vu meter reads 0 vu (100%) the actual audio level is a +4 dbm. As noted before, a 30-db pad was inserted in the output to match the input level of the professional tape recorder used by the studio. This may or may not suit your application. A variable T- or H-pad could be inserted in place of the fixed pad but this refinement would be quite expensive, unnecessary, and would take up considerable space. However, if different levels are frequently required, the variable pad might be the most satisfactory solution in this instance.

Frequency response	
0 db to −1 db, 30-18,000 cps	
Max. harmonic distortion	0.67%
Hum & Noise (max.)	−56 db
Inputs	
Four low impedance (50 ohms), one convertible to a high-impedance bridging input	

Table 1. Summary of specifications.

In addition to the four low-impedance inputs, a bridging input is provided which utilizes one of the microphone channels. This was done to insure facilities for transcribed background and special effects when needed in the field. Because space was at a premium, normalling (closed-circuit) jacks were not used. Instead, *RCA*-type phono jacks were used (J_3 and J_4) and connected directly to the transformer T_4 with R_{35} and R_{36}. To work properly, a plug should be inserted into the unused microphone channel (J_4) with a terminating resistor (R_{41}) as shown in the schematic. This resistor should be equal to the impedance of the microphone normally used at this input. It might be noted that while this method not only saved space, it was also no more expensive than the other alternative—that of using a switch to terminate and disconnect the input.

Power Supply

No mention has been made previously about the power supply. It is not critical and any conventional supply that is well filtered and is capable of delivering 250 volts d.c. at 25 ma. will do. An electronically regulated, variable-voltage power supply was used in the test set-up and for final checking of the mixer components. However, after the "B+" requirements were determined, a small, compact supply was built (Fig. 3) and placed at the end of a six-foot cable. This is a good practice to follow whenever low-level transformers are involved, even when they have exceptionally good shielding. All final performance figures (see Table 1 and Fig. 4) were obtained using this supply.

While this power supply provides adequate performance, it might be frowned upon by some. However, it is compact, generates little heat, and used parts the author had on hand at the time of construction. The main objection to voltage doublers is their poorer voltage regulation under variable loads. This supply requires very little current to begin with and, by using silicon diodes, the only current-limiting factor is the power transformer. One side of the preamp filaments is connected to a d.c. potential of approximately 70 volts by means of a voltage divider, R_{37}-R_{38}, to the 230-volt supply line. This positive biasing of the filament line is another precautionary measure to insure against hum.

The power transformer used (T_6) was unable to provide the extra current needed for the output tube so a filament

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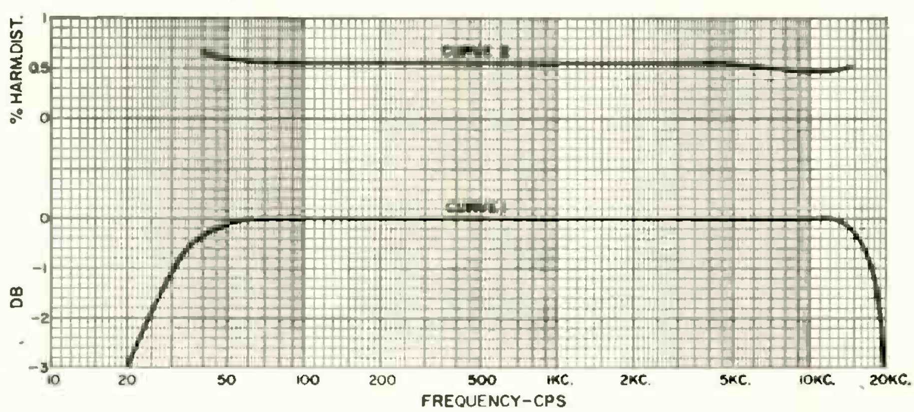
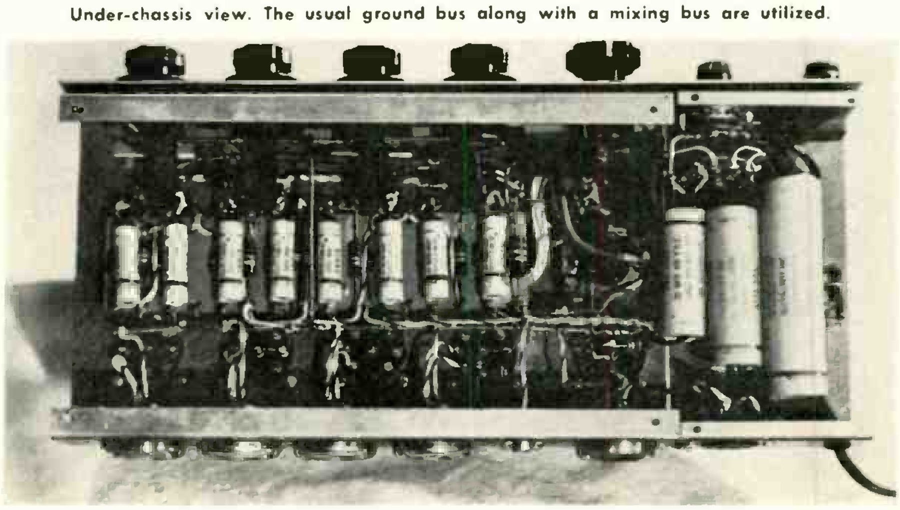
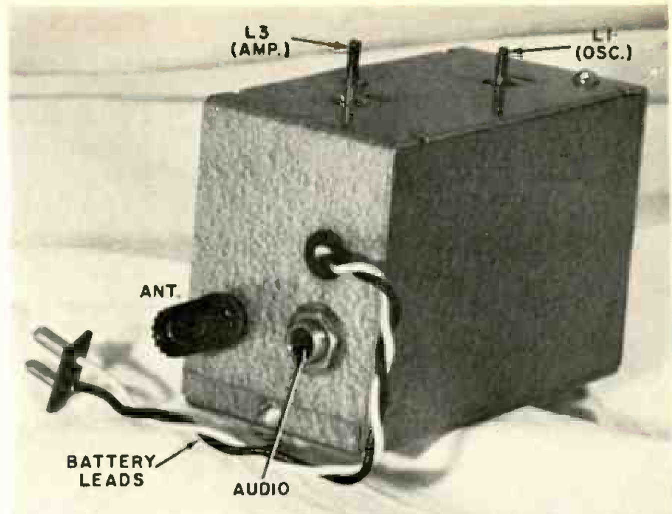


Fig. 4. Curve 1 shows frequency response, curve 2 shows distortion of the mixer.

Under-chassis view. The usual ground bus along with a mixing bus are utilized.



TRANSISTORIZED TRANSMITTER FOR COLLEGE STATIONS



Each transmitter is housed in a 3¼" x 2⅛" x 1⅝" aluminum box.

By **THOMAS J. BARMORE** / Washington State University

A number of these micro-powered transmitters, which require no licensing at all, may be placed throughout the campus for complete coverage.

THERE are quite a few student broadcast stations now operating on college campuses all over the United States. These limited-power stations usually fall into one of two categories: those which are licensed and transmit with low or medium power, and those which use the carrier-current method of transmission.

A carrier-current transmitter usually is a low-power AM transmitter which does not radiate in the usual manner. In fact, the system utilizes the power lines as a direct transmission path to the listener's receiver. The disadvantage in this method is that radiation must necessarily cease when the power line is interrupted by a line transformer or any other obstacle in the power line.

If this is the case, it becomes necessary to consider transmitters that will carry a broadcast signal any distance without worrying about transmission lines and ones not powerful enough to require licensing. The answer to this problem is to use several transmitters of low enough power so that licensing is not required, placed at different locations throughout the campus, and supplied with an audio signal of the proper amplitude.

Here at Washington State University, we are presently using such a system. This system utilizes a standard audio console, a network of balanced audio feedlines, along with ten battery-operated transistorized transmitters.

Circuit Design

The transmitters used are two-stage, crystal-controlled, 670-kc., 400-microwatt units. See Fig. 1. Harmonic distortion is less than 1% at 100% modulation and the unit will accept modulation from 1 cycle to 50 kc. with no frequency distortion. 100% modulation occurs with an audio signal of 1 volt r.m.s.

The oscillator is a conventional grounded-emitter Pierce configuration, with base stabilization furnished by resistor R_1. The output is developed across L_1 and couples to the emitter of V_2.

The final amplifier is a grounded-base,

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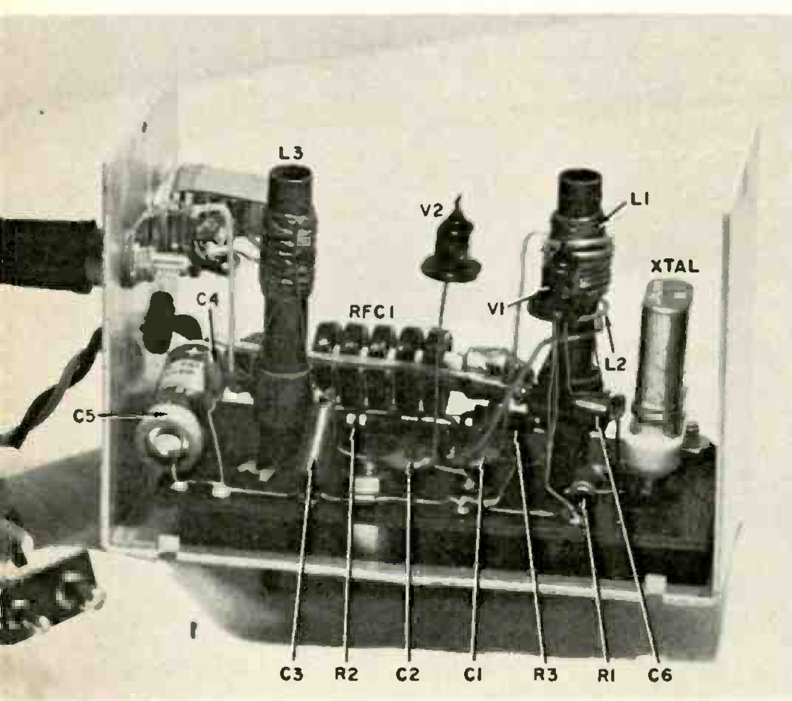
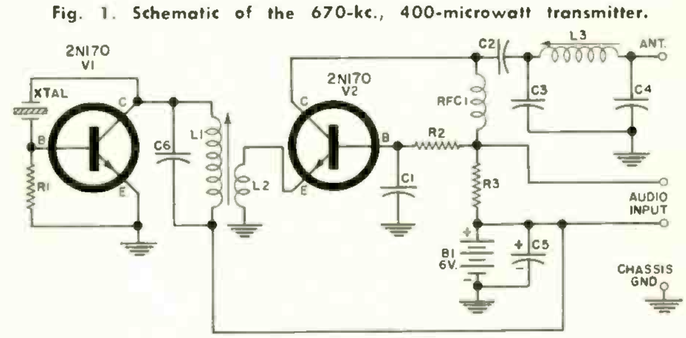


◀The chassis board is a 1½" x 3" piece of cloth-base phenolic.

Fig. 1. Schematic of the 670-kc., 400-microwatt transmitter.



R_1,R_2—150,000 ohm, ½ w. res.
R_3—1800 ohm, ½ w. res.
C_1—.002 µf., 100 v. ceramic capacitor
C_2,C_4—.001 µf., 100 v. ceramic capacitor
C_3,C_6—300 µµf., 100 v. ceramic capacitor
C_5—10 µf., 10 v. elec. capacitor
L_1,L_3—40-300 µhy. ferrite-core antenna for use with 250-450 µµf. capacitor (J. W. Miller Type 2002)
L_2—8 t. #22 wire, wrapped around bottom of L_1 and insulated from it.
RFC—10 mhy. r.f. choke
Xtal—670-kc. crystal
B_1—6-volt battery (Eveready 744 or equiv.)
V_1,V_2—"n-p-n" transistor (General Electric 2N170)

RC equalization curves

By HERMAN BURSTEIN

An accurate graphic method for the audio technician of charting any equalization curve, such as those used for tone control and for disc and tape recording.

THOSE seriously involved in the field of audio must be on familiar terms with *RC* equalization curves, which play a vital role in audio equipment.

The reference is to curves produced by simple resistor-capacitor circuits which cause frequency response to shift from a flat characteristic until it attains a rate of rise or fall proportional to change in frequency. The part of an *RC* equalization curve that changes in proportion to frequency does so at the rate of 6 db per octave or 20 db per decade.

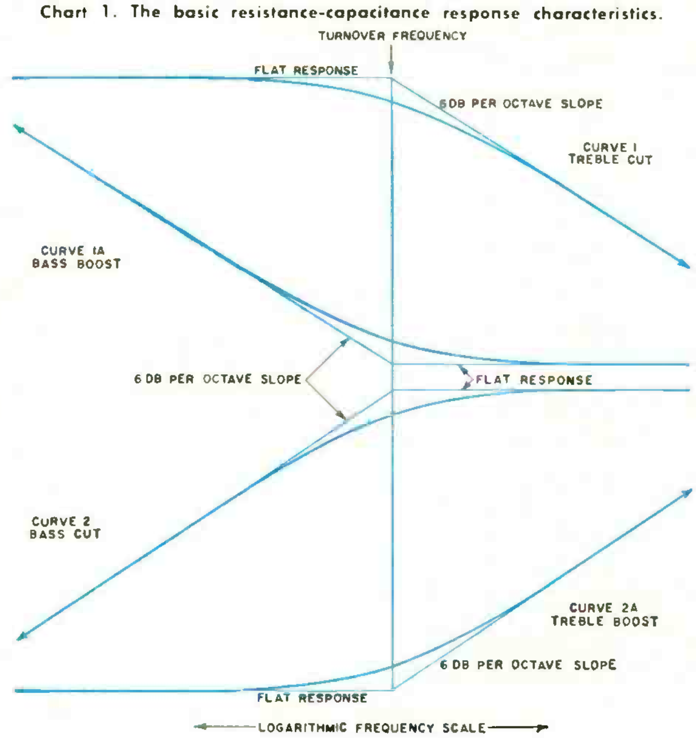
The equalization curves to be discussed here are the well-known standard characteristics employed for FM de-emphasis, for playback of phono discs, and for playback of tape. They are also the complementary equalization characteristics employed in FM broadcasting and in disc recording.

It frequently becomes necessary to plot one of these standard, or even nonstandard, *RC* curves in order to ascertain with exactness how signal amplitude varies as frequency changes. In the case of standard curves, copies of them are not always at hand and even when they are it is not always possible to read them with the desired precision. It may be that the grid lines are, for example, at 5-db intervals, whereas closer spacing is required for reasonably accurate reading. Or, given an accurate copy of a standard curve, it may turn out that it is on the wrong size audio log paper for tracing in order to compare it with the performance of a piece of equipment; instead, it must be copied point by point.

For these and other reasons, the job of plotting an equalization curve point by point often arises. This is a tedious business at best. Therefore, it is the purpose of this article to describe a quick, graphic method of charting an equalization curve, standard or not. In most circumstances the method is accurate within ¼ db or less; at the outside the error is about ½ db.

The graphic technique relies on two basic graphs, which are traced to delineate the desired equalization characteristic. It is only necessary to know the time constants—or turnover frequencies—of the curve in order to trace swiftly and with sufficient accuracy for most practical applications.

Chart 1. The basic resistance-capacitance response characteristics.

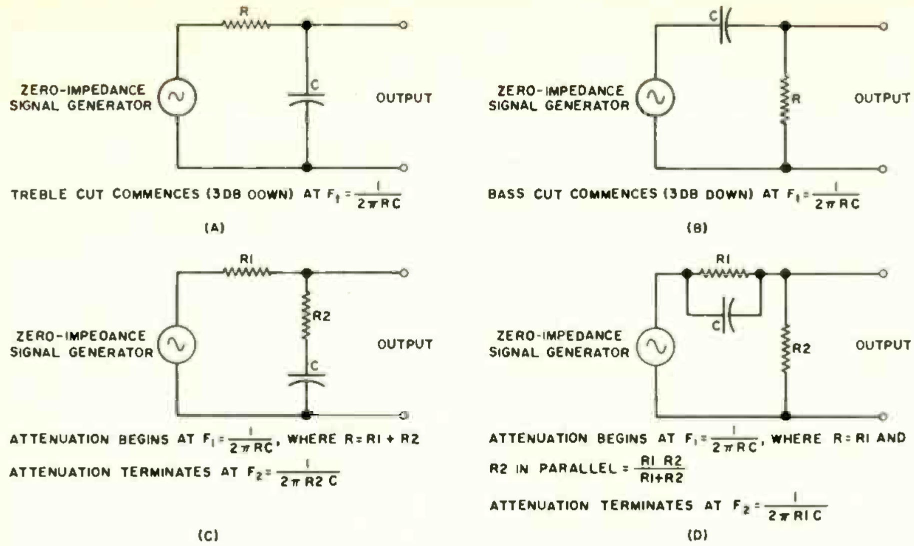


Before describing the technique of drawing *RC* equalization curves, or computing the values of points to be plotted, it is important to first discuss the nature of these curves.

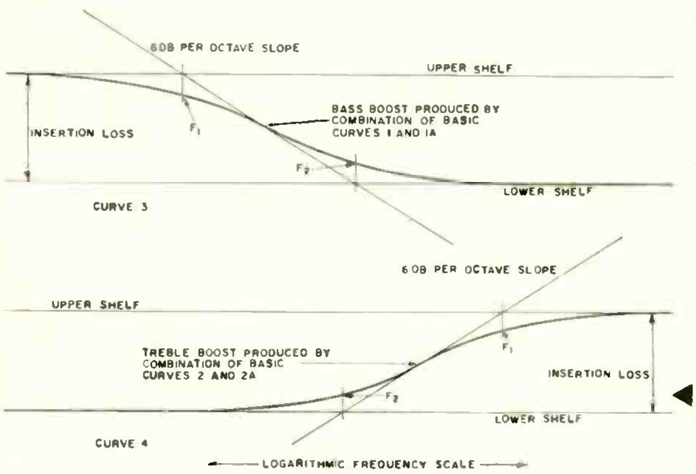
Basic RC Curves

Chart 1 shows the four basic types of *RC* curves. Starting at a level, or shelf, where response is flat, each curve proceeds to rise or fall until it attains a maximum rate of 6 db per octave. The frequency at which the curve has risen 3 db above the shelf or fallen 3 db below the shelf is termed the ***turnover frequency***, 3-db point, or sometimes the inflection point. The turnover frequency, F_t, is determined by the *RC*—resistance and capacitance—values employed in the equalization circuit: $F_t = 1/(2\pi RC)$.

In *RC* circuits where the rise or the fall in response



▲ Fig. 1. (A) A circuit producing treble cut according to Curve 1 in Chart 1. (B) Circuit producing bass cut according to Curve 2 shown in Chart 1. (C) Circuit producing bass boost according to Curve 3 shown in Chart 2. (D) Circuit producing treble boost according to Curve 4 shown in Chart 2.



◀ Chart 2. Bass and treble boost produced by combining basic curves.

is terminated before it can reach 6 db per octave, somewhat less than a 3-db change is achieved at the turnover frequency. Nonetheless, the turnover frequency, which depends on the *RC* time constant of the circuit, remains the same. Therefore it is best to avoid the expression "3-db point" and instead use the term "turnover frequency," although the two are quite often the same.

The rise or fall of an equalization curve is said to begin at the turnover frequency. If the curve is employed to terminate a previous rise or fall in bass or treble response, it may be said that the rise or fall terminates at the turnover frequency. Curve 1 in Chart 1 is treble cut, produced by the circuit of Fig. 1A. Curve 1A is bass boost. It cannot be produced purely as shown, because bass boost is actually achieved by reducing the treble frequencies. We will come to the practical circuit shortly. Note that rotating Curve 1 180 degrees produces Curve 1A. We shall take advantage of this later.

Curve 2 is bass cut, produced by the circuit of Fig. 1B. Curve 2A is treble boost, which cannot be produced purely as represented, because treble boost is actually achieved by reducing the bass frequencies. We shall discuss a practical circuit along these lines presently. Note that rotating Curve 2 180 degrees produces Curve 2A.

These four basic curves are combined to produce practical bass boost and treble boost curves, as shown in Chart 2.

Curve 3 represents a practical bass boost curve, produced by the circuit of Fig. 1C. Curve 3 is a combination of Curves 1 and 1A. It may also be viewed as limited treble cut (as distinguished from the infinite treble cut of Curve 1). Whether it is bass boost or treble cut depends on the choice of turnover frequencies. If turnover frequency F_1 is well up in the audio range, the curve becomes treble cut. If F_2 occurs toward the middle or low end of the audio range, the curve becomes bass boost. Note that if F_1 is moved below the audio range, the portion of the curve remaining *within* the range is the same as Curve 1A. If F_2 is moved above the audio range, the portion of the curve remaining *within* the range is the same as Curve 1.

Curve 4 represents a practical treble boost curve, produced by the circuit of Fig. 1D. Curve 4 is a combination of Curves 2 and 2A. Curve 4 may also be viewed as limited bass cut (as distinguished from the infinite bass cut of Curve 2). Whether it is treble boost or bass cut depends on the choice of turnover frequencies, in a manner similar to Curve 3.

Standard Equalization Curves

Figs. 2, 3, and 4 show the well-known FM de-emphasis, RIAA disc playback, and NAB tape playback curves respectively. Fig. 5 is the 3.75-ips tape playback curve which is coming into vogue. Following are the characteristics of each curve.

FM De-emphasis: This consists of infinite treble cut employed in FM reception (and in the sound portion of TV). Attenuation begins at 2122 cycles. FM de-emphasis is produced by Basic Curve 1.

RIAA Disc Playback: This consists of bass boost and treble cut, assuming that a velocity pickup is used. Bass boost begins at 500 cycles and terminates at 50 cycles. Total bass boost is 20 db. This portion of the RIAA characteristic consists of Basic Curves 1 and 1A. Treble cut commences at 2122 cycles, just as in the case of FM de-emphasis; it is produced by Basic Curve 1.

NAB Tape Playback (15 and 7.5 ips): This consists entirely of bass boost, beginning at the relatively high frequency of 3180 cycles and terminating at 50 cycles. Total boost is 36 db. It is produced by Basic Curves 1 and 1A. The NAB characteristic is frequently drawn so that the 0 db point occurs at 1000 cycles, which makes it appear that there is 26-db bass boost below 1000 cycles and 10-db treble cut above 1000 cycles. Actually, there is no treble cut as such.

3.75-ips Tape Playback: This is essentially the same as the NAB curve except that the bass boost starts at 1326 cycles instead of 3180 cycles. Total boost is 28.3 db.

The foregoing data is summarized in Table 1, which also presents the time constants corresponding to the turnover frequencies.

None of the standard curves just discussed employs Basic Curves 2 and 2A. However, if one is concerned with the equalization used in FM broadcasting and in disc recording, then Curves 2 and 2A come into play to achieve bass cut or treble boost. The FM pre-emphasis curve used by broadcasters is the complement of the one shown in Fig. 2. It corresponds to Basic Curve 2A (the practical circuit causes the treble boost to terminate beyond the end of the audio range). RIAA equalization used in recording is the complement of the curve of Fig. 3. It consists of Basic Curves 2 and 2A.

Drawing a Curve

To draw any standard or non-standard *RC* curve with accuracy, based on knowledge of the turnover frequency or frequencies, you will need only Graphs 1 and 2. Graph 1 presents Basic Curve 1 on audio log paper; by turning it upside down (180-degree rotation), you also have Basic Curve 1A. In the same fashion, Graph 2 presents Basic Curves 2 and 2A on audio log paper. Note that on each graph the turnover frequency is marked. This is the particular frequency value at which the

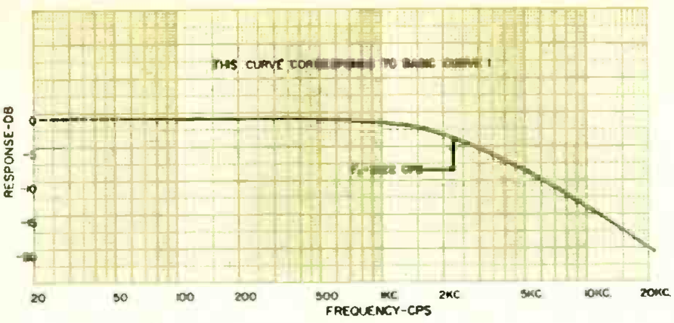


Fig. 2. The standard FM receiver de-emphasis curve.

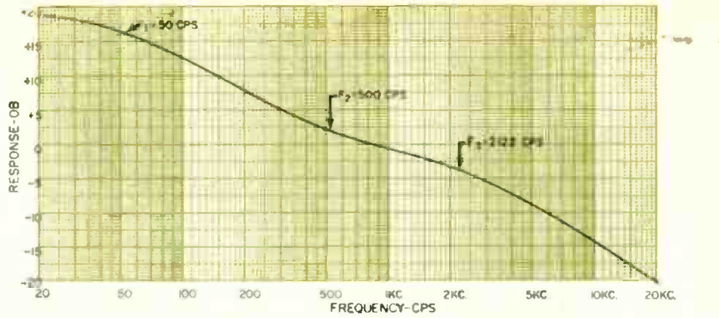


Fig. 3. The standard RIAA phono disc playback curve.

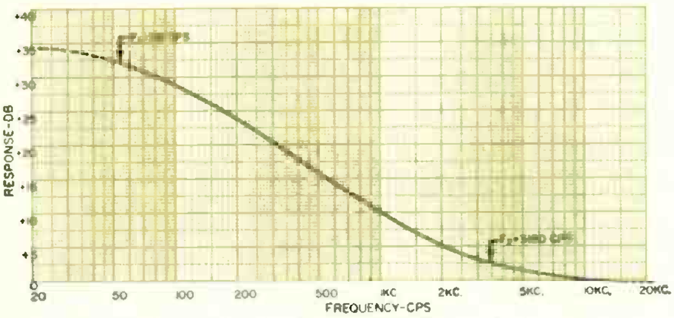


Fig. 4. The standard NAB tape recording playback curve.

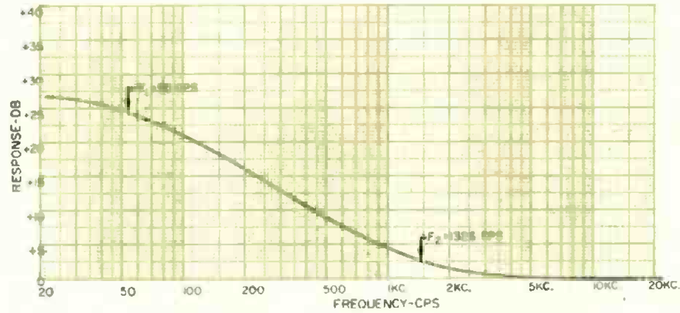
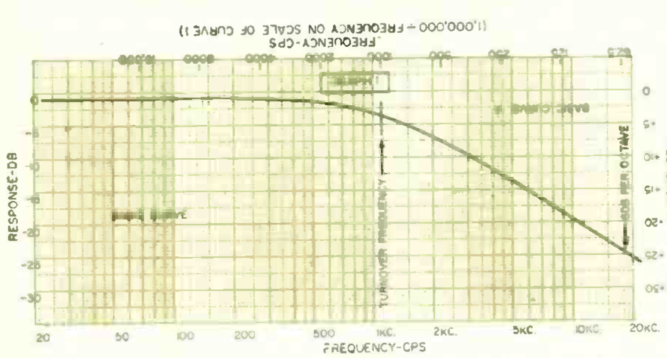
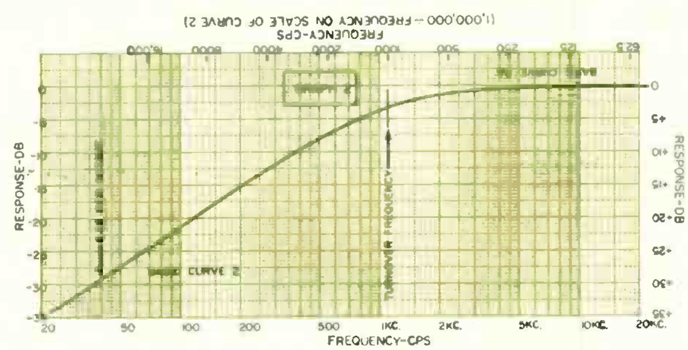


Fig. 5. The widely used 3¾-ips tape playback curve.



Graph 1. Basic Curves 1, 1A for treble roll-off, bass boost.



Graph 2. Basic Curves 2, 2A for bass roll-off, treble boost.

circuit response is reduced by 3 db.

In order to permit accurate copies of Graphs 1 and 2, Table 2 lists the required values, in decibels, for plotting Curves 1 and 2. These curves should be plotted on the same kind of audio log paper that you plan to use for drawing various *RC* curves. After plotting the values of Table 2, connect them with a French curve or other suitable smoothing device. Even careful freehand smoothing will be satisfactory for most purposes. The final curve should be dark to facilitate tracing.

The FM De-emphasis Curve

The FM de-emphasis curve consists of treble attenuation beginning at 2122 cycles. If the turnover is stated as a time constant, 75 μsec. in the present case, the turnover frequency is obtained by dividing the time constant (in microseconds) into 159,155 (which is 1,000,000 divided by 2π). Thus 159,155 divided by 75 is 2122.

The procedure for constructing the FM de-emphasis curve is as follows:

1. Place a transparent sheet of audio log paper over the sheet on which you have drawn Basic Curve 1. Of course both sheets must be to the same scale. Locate the upper sheet so that the turnover frequency marked on Basic Curve 1 corresponds to 2122 cycles and so that the flat portion of Basic Curve 1 is at the level designated "0 db" on the upper sheet. Trace Basic Curve 1.

2. You will find that the tracing does not fully cover the lower part of the audio range, because the turnover frequency of Basic Curve 1 is 1000 cycles, whereas the turnover for the FM de-emphasis curve is 2122 cycles. However, Basic Curve 1 has reached its flat portion by the time it has "run out" for tracing purposes. Therefore, extend response into the bass region simply by using a straightedge to draw a horizontal continuation of the curve you are constructing. Conversely, if you were constructing an attenuation curve which begins below 1000 cycles, the drawing would be incomplete at the upper end of the audio range. Again there is no problem. By the time Curve 1 has "run out" in the treble area it has reached a 6-db-per-octave slope. Therefore extend response into the treble region simply by using a straightedge to draw a continuation line that slopes 6 db per octave.

NAB Tape Playback Curve

The NAB curve consists of bass boost beginning at 3180 cycles and terminat-

Table 1. Turnover frequencies, time constants of four standard equalization curves.

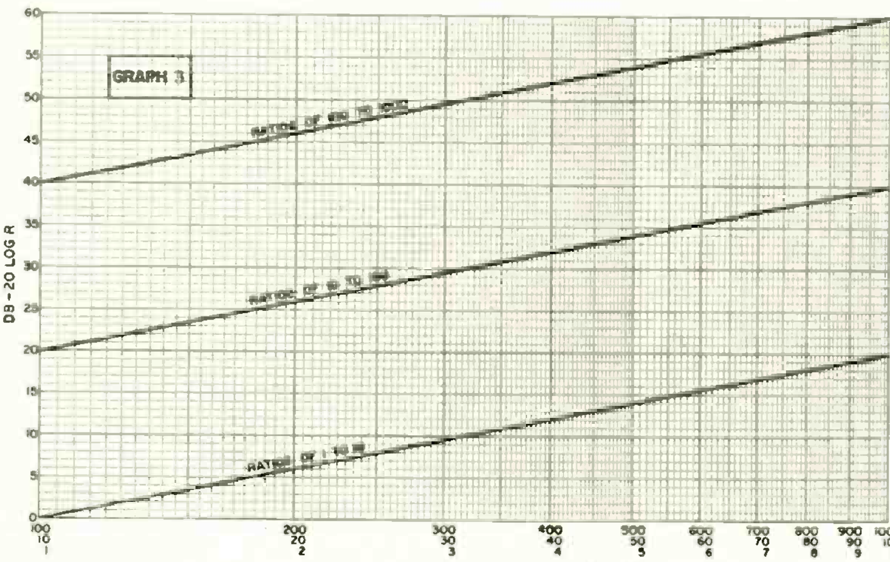
	FM De-Emphasis	NAB Tape Playback	3.75-ips Tape Playback	RIAA Disc Playback
Turnover Frequencies (cps)				
F_1—Attenuation begins	A 2122	B { 50	C { 50	D { 50
F_2—Attenuation terminates	——	3180	1326	500
F_3—Attenuation begins again	——	——	——	2122
Corresponding Time Constants (μsec.)				
T_1 for F_1	75	3180	3180	3180
T_2 for F_2	——	50	125	318
T_3 for F_3	——	——	——	75

A. Treble cut; B. Bass boost, with 36 db insertion loss; C. Bass boost, with 28.3 db insertion loss; D. Bass boost, with 20 db insertion loss.

BASIC CURVE 1		BASIC CURVE 1		BASIC CURVE 2		BASIC CURVE 2	
Freq. (cps)	Atten. (db)	Freq. (cps)	Atten. (db)	Freq. (cps)	Atten. (db)	Freq. (cps)	Atten. (db)
20	0.00	1,300	4.30	20,000	0.01	900	3.49
*31.25	0.00	1,400	4.71	*16,000	0.02	800	4.09
50	0.01	1,500	5.12	10,000	0.04	700	4.83
*62.5	0.02	1,600	5.52	*8,000	0.07	600	5.77
100	0.04	1,800	6.27	7,000	0.09	500	6.99
*125	0.07	*2,000	6.99	6,000	0.12	450	7.74
150	0.10	2,400	8.30	5,000	0.17	400	8.60
200	0.17	2,800	9.46	*4,000	0.26	350	9.62
*250	0.26	3,200	10.51	3,600	0.32	300	10.83
300	0.37	3,600	11.45	3,200	0.41	*250	12.30
350	0.50	*4,000	12.30	2,800	0.52	200	14.15
400	0.64	4,500	13.27	2,400	0.70	150	16.57
450	0.80	5,000	14.15	*2,000	0.97	*125	18.13
*500	0.97	6,000	15.68	1,800	1.17	100	20.04
600	1.34	7,000	16.99	1,600	1.43	75	22.53
700	1.73	*8,000	18.13	1,400	1.79	*62.5	24.10
800	2.15	9,000	19.14	1,300	2.02	50	26.03
900	2.58	10,000	20.04	1,200	2.29	*31.25	30.11
*1,000	3.01	12,000	21.61	1,100	2.62	25	32.04
1,100	3.44	*16,000	24.10	*1,000	3.01	20	33.98
1,200	3.87	20,000	26.03				

*Octave frequencies relative to 1000 cps.

Table 2. The exact values to be employed in plotting the basic Curves 1 and 2.



Graph 3. Ratios between turnover frequencies, expressed as decibels gain or loss.

ing at 50 cycles. The construction procedure is as follows:

1. Determine the insertion loss, namely the total bass boost in decibels. This is computed as 20 times the log of the ratio between the turnover frequencies: divide the higher turnover frequency by the lower one. In the present example, the ratio between turnover frequencies is 63.6; the log of 63.6 is 18; and 20 times 18 is 36 (db). If you don't have a table of logarithms, use Graph 3 instead. To illustrate its use in the present example: Follow the horizontal axis out to the point corresponding to a ratio of 63.6. Move vertically to the middle line, which applies to ratios between 10 and 100. From this intersection move horizontally to the left scale, which reads 36 db.

2. On a sheet of audio log paper, draw two horizontal lines 36 db apart, corresponding to the insertion loss. These are designated the "upper shelf" and the "lower shelf," with the latter being on the 0 db level.

3. Determine the mean frequency, F_m, between the two turnover frequencies. F_m may be calculated as $\sqrt{F_1 \times F_2}$, where F_1 and F_2 are the two turnover frequencies. But much the easier way, when using audio log paper, is to measure half-way between 50 and 3180 cycles. Mark F_m, which is 399 cycles, at half the distance between the upper and lower shelves, namely at the 18 db level.

4. Turn Graph 1 upside down so that it becomes Basic Curve 1A. Place a sheet of audio log paper over Basic Curve 1A so that the turnover frequency corresponds to 3180 cycles; and so that the flat portion of the Basic Curve is at the 0 db level, coinciding with the lower shelf. Trace Basic Curve 1A until you come to point F_m on the upper sheet.

5. Return to Basic Curve 1 (by turning Graph 1 upside down again). Locate the turnover frequency so that it corresponds to 50 cycles on the upper sheet; and so that the flat portion of the curve coincides with the upper shelf. Trace Basic Curve 1A until you come to point F_m. At F_m you should run into the other half of your drawing unless: (a) You have done something wrong. (b) The two turnover frequencies are less than four octaves apart; in other words, form a ratio of less than 16:1. In the case of the NAB curve, the ratio is 63.6, and the two tracings will meet.

RIAA Disc Playback Curve

The RIAA curve consists of bass boost with turnover frequencies of 50 and 500 cycles; and of infinite treble cut with a turnover frequency of 2122 cycles.

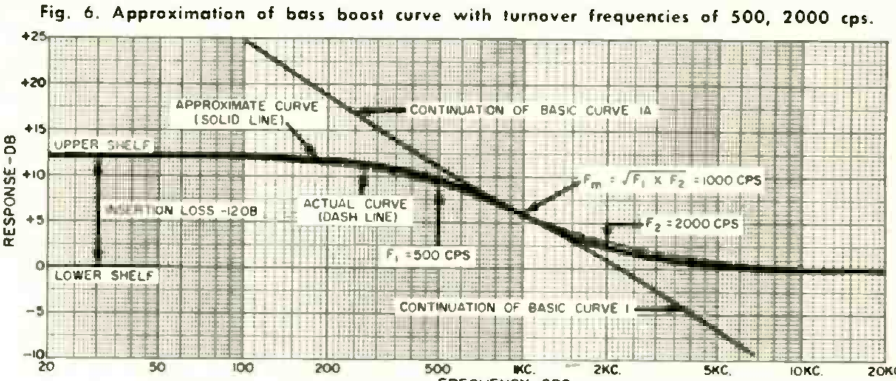
Starting from the turnover frequency, an *RC* curve requires two octaves in either direction to become essentially a straight line—either flat or sloping 6 db per octave.

If an *RC* curve has two turnover frequencies, there is interaction between them: The upper portion of the curve is governed not only by the upper turnover frequency but also, to a lesser extent, by the lower frequency; therefore the upper portion changes shape somewhat. In the same way, the lower portion of the curve is governed by the upper turnover frequency as well as by the lower frequency. When the two turnover frequencies are at least four octaves apart—a ratio of 16:1 or greater—the amount of interaction is insignificant because each portion of the curve has become linear. Therefore, the upper half of the curve can be drawn independently of the lower half, as in the case of the NAB curve.

But if the turnover frequencies are less than four octaves apart, there is interaction and the upper and lower halves of the curve are not exactly the same as Basic Curves 1, 1A, 2, and 2A. This is the situation encountered in dealing with the bass boost portion of the RIAA curve, where the ratio between turnover frequencies is 10:1.

(*Continued on page* 62)

Fig. 6. Approximation of bass boost curve with turnover frequencies of 500, 2000 cps.



CALENDAR of EVENTS

MARCH 26-29
IRE International Convention. Sponsored by all Professional Groups of the IRE. Coliseum & Waldorf-Astoria Hotel, New York, N.Y. Details from E. K. Gannett, IRE Headquarters, 1 E. 79th St., New York 21, N.Y.

MARCH 28-29
Third Symposium on Engineering Aspects of Magnetohydrodynamics. Sponsored by AIEE, IAS, IRE, and University of Rochester. University of Rochester, Rochester, N.Y. Chairman of program committee, George W. Sutton, MIT, Room 3-254, Cambridge 39, Mass.

MARCH 28-31
Eleventh Biennial Electrical Industry Show. Sponsored by Electrical Maintenance Engineers Association of California. Shrine Exposition Hall, Los Angeles.

MARCH 29
Seventh Annual Materials Handling and Packaging Conference. Sponsored by Northern California Chapter of AMHS and the Golden Gate and Central California Chapters of SPHE. Stanford University, Palo Alto, Calif.

APRIL 4-6
1962 E.M.R.A. Electrical Exhibit. Sponsored by Electrical Manufacturers Representatives Assn. of Michigan. Detroit Artillery Armory, Detroit, Michigan.

APRIL 11-13
1962 Southwestern IRE Conference. Sponsored by IRE, Region 6. Rice Hotel, Houston, Texas.

APRIL 25-29
Western Space Age Industries and Engineering Exposition & Conference. Cow Palace, San Francisco. Information from Lykke-Wilkins & Assoc., 681 Market St., San Francisco 5, Calif.

APRIL 29-MAY 4
91st Convention SMPTE. Sponsored by Society of Motion Picture and Television Engineers. "Advances in Color Motion Pictures and Color Television." Ambassador Hotel, Los Angeles. Details from SMPTE at 55 W. 42nd St., New York 36, N.Y.

MAY 1-3
Ninth Annual Cleveland Electronics Conference. Sponsored by IRE, AIEE, ISA, Case Institute of Technology, Western Reserve University, Cleveland Physics Society. Engineering & Scientific Center, Cleveland, Ohio. Program details from Lapine Enterprises, 310 Hotel Manger, Cleveland 14, Ohio.

MAY 2-5
13th National Science Fair-International. Sponsored by Science Service. Seattle, Washington. Details from Science Service, 1719 N. Street N.W., Washington 6, D.C.

MAY 3-4
International Congress on Human Factors in Electronics. Sponsored by the Los Angeles Chapter of PGHFE of IRE. Lafayette Hotel, Long Beach, Calif. Details from Dr. Charles Hopkins, Symposium Chairman, Hughes Aircraft Co., Culver City, Calif.

MAY 8-10
1962 Electronic Components Conference. Sponsored by AIEE, EIA, and IRE. Mariott Twin Bridges Motor Hotel, Washington, D.C.

MAY 14-16
Fourteenth Annual National Aerospace Electronics Conference. Sponsored by Dayton Section of IRE and PGANE. Dayton Biltmore Hotel and Memorial Hall, Dayton, Ohio. Details from IRE, 1 E. 79th St., New York 21, N.Y.

MAY 15-17
Fourth Annual Meeting of Council on Medical TV & Medical-Dental TV Workshop. Sponsored by the Council on Medical Television. Clinical Center, National Institutes of Health, Bethesda, Md. and National Naval Medical Center, Bethesda. Details from Institute for Advancement of Medical Communication, 33 E. 68th St., New York 21.

MAY 21-24
1962 Electronic Parts Distributors Show. Sponsored by EP&EM, EIA, PACE, WEMA, and ERA. Conrad Hilton Hotel, Chicago. Open only to qualified industry members.

MAY 22-24
National Microwave Theory & Techniques Symposium. Sponsored by PGMITT of IRE. Boulder Laboratories of National Bureau of Standards, Boulder, Colorado.

MAY 23-25
11th National Telemetering Conference. Sponsored by ISA, ARS, IAS, AIEE, IRE. Sheraton-Park Hotel, Washington, D.C.

MAY 24-26
Seventh Region Conference. Sponsored by the Seattle Section of IRE. "Space Communications." Seattle, Washington. Program information from IRE, 1 E. 79th St., New York 21, N.Y.

MAY 31-JUNE 7
International Television Conference. Sponsored by Electronics and Communications Section of the Institution of Electrical Engineers. Institution Bldg., Savoy Place, London W.C. 2, England.

JUNE 11-15
Technical Writers' Institute. Rensselaer Polytechnic Institute, Troy, N.Y. Information on course from Prof. Jay R. Gould, RPI, Troy, N.Y.

JUNE 24-28
Music Industry Trade Show. Sponsored by the National Association of Music Merchants. Hotel New Yorker, New York City.

JUNE 25-30
Symposium on Electromagnetic Theory and Antennas. Sponsored by the IRE. The Technical University of Denmark, Copenhagen. Information from IRE, 1 E. 79th St., New York 21, N.Y. ▲

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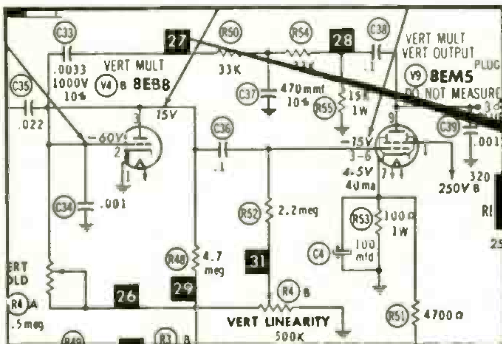

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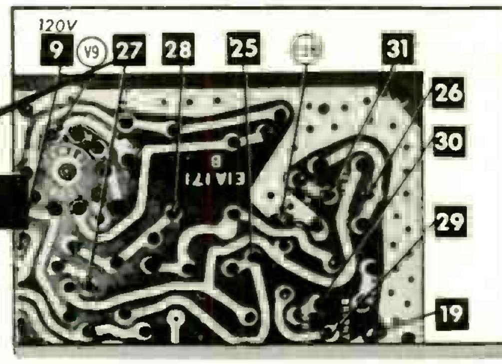

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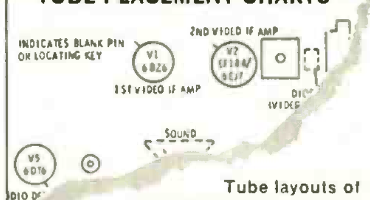

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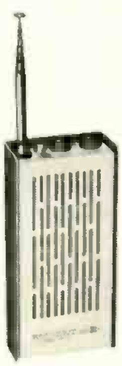

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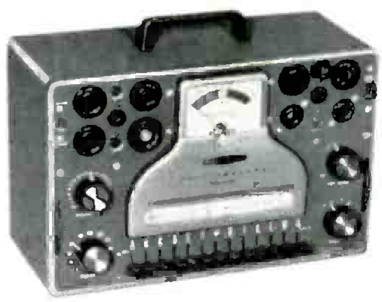

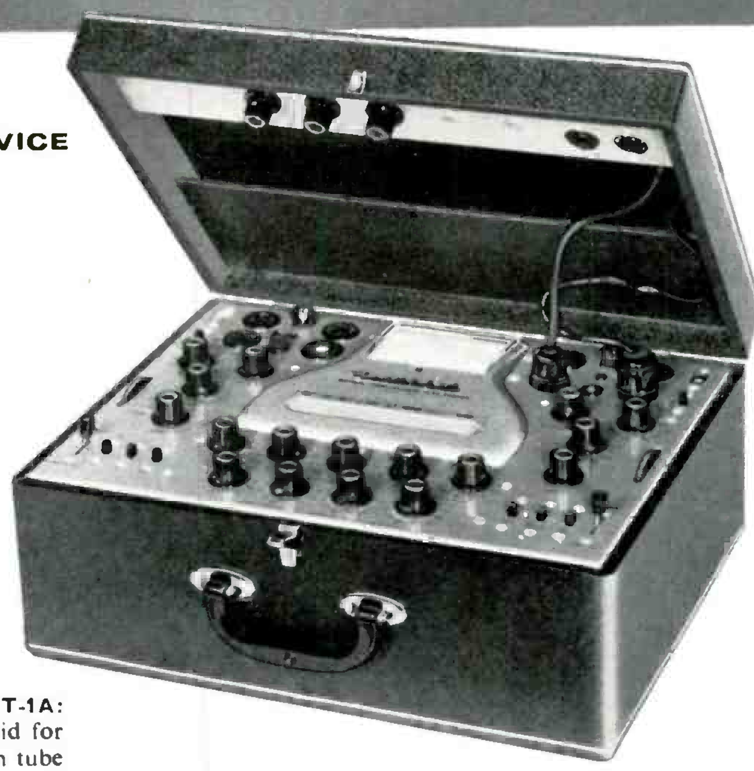

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ITEM	MODEL NO.	PRICE

RC Equalization Curves

(*Continued from page* 56)

On the other hand, it is possible to represent each half of the bass boost characteristic by means of the Basic Curves if we are willing to settle for an approximation which is accurate within ½ db or better.

Fig. 6 illustrates the approximation technique for a bass boost curve with the very low ratio of 4:1 between turnover frequencies; 500 and 2000 cycles are used in this example. The procedure is as follows:

1. As explained in the preceding example, determine the insertion loss (12 db) and draw the corresponding upper and lower shelves on a sheet of audio log paper. Determine F_m (1000 cycles) and mark it as a point at half the insertion loss (6 db level).

2. Place the audio log paper over Basic Curve 1A so that the turnover frequency corresponds to 2000 cycles; and so that the flat portion of the Basic Curve coincides with the lower shelf. Now slide the upper sheet to the right until Basic Curve 1A goes through point F_m, as marked on the upper sheet. Trace Basic Curve 1A as far as F_m.

3. Place the audio log paper over Basic Curve 1 so that the turnover frequency corresponds to 500 cycles; and so that the flat portion of the Basic Curve coincides with the upper shelf. Slide the upper sheet to the left until Basic Curve 1 goes through point F_m. Trace Basic Curve 1 as far as F_m.

Fig. 6 shows not only the approximate equalization curve for turnover frequencies of 500 and 2000 cycles, but also the exact curve. It may be seen that even though the turnover ratio is only 4:1, the error of the approximate curve is ½ db at worst. When the turnover ratio becomes as great as 10:1, which is the case for the bass boost portion of the RIAA curve, the error becomes much less than ½ db.

Fig. 7 illustrates the construction of the RIAA curve by the graphic method. The bass boost portion is drawn in the same manner as has been described for the bass boost curve of Fig. 6. However, the RIAA curve also contains treble cut. Moreover, there is less than a 16:1 ratio between the turnover ratios representing the beginning of bass boost (500 cycles) and the beginning of treble cut (2122 cycles). Therefore an approximation technique is required to merge the treble cut portion with the bass boost portion of the RIAA curve. The entire procedure is as follows:

1. In the same manner as for Fig. 6, draw the RIAA bass boost curve, based on an insertion loss of 20 db, with the upper and lower halves of the curve going to point F_{m1}, which is 158 cycles. The curve drawn thus far is represented by curve A-B in Fig. 7. The next step is to add treble cut.

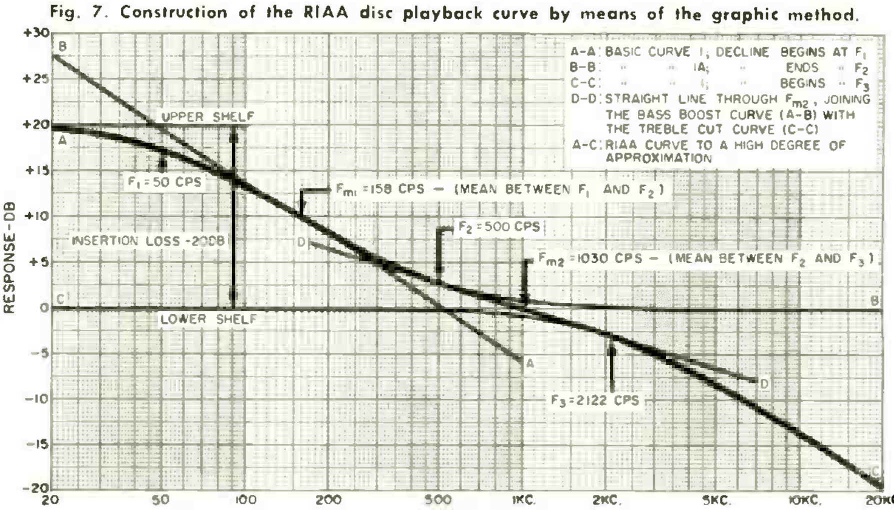
2. Place the drawing over Basic Curve 1 so that the turnover frequency corresponds to 500 cycles; and so that the flat portion coincides with the lower shelf. Trace Basic Curve 1; this results in curve C-C in Fig. 7. It remains to join curves A-B and C-C.

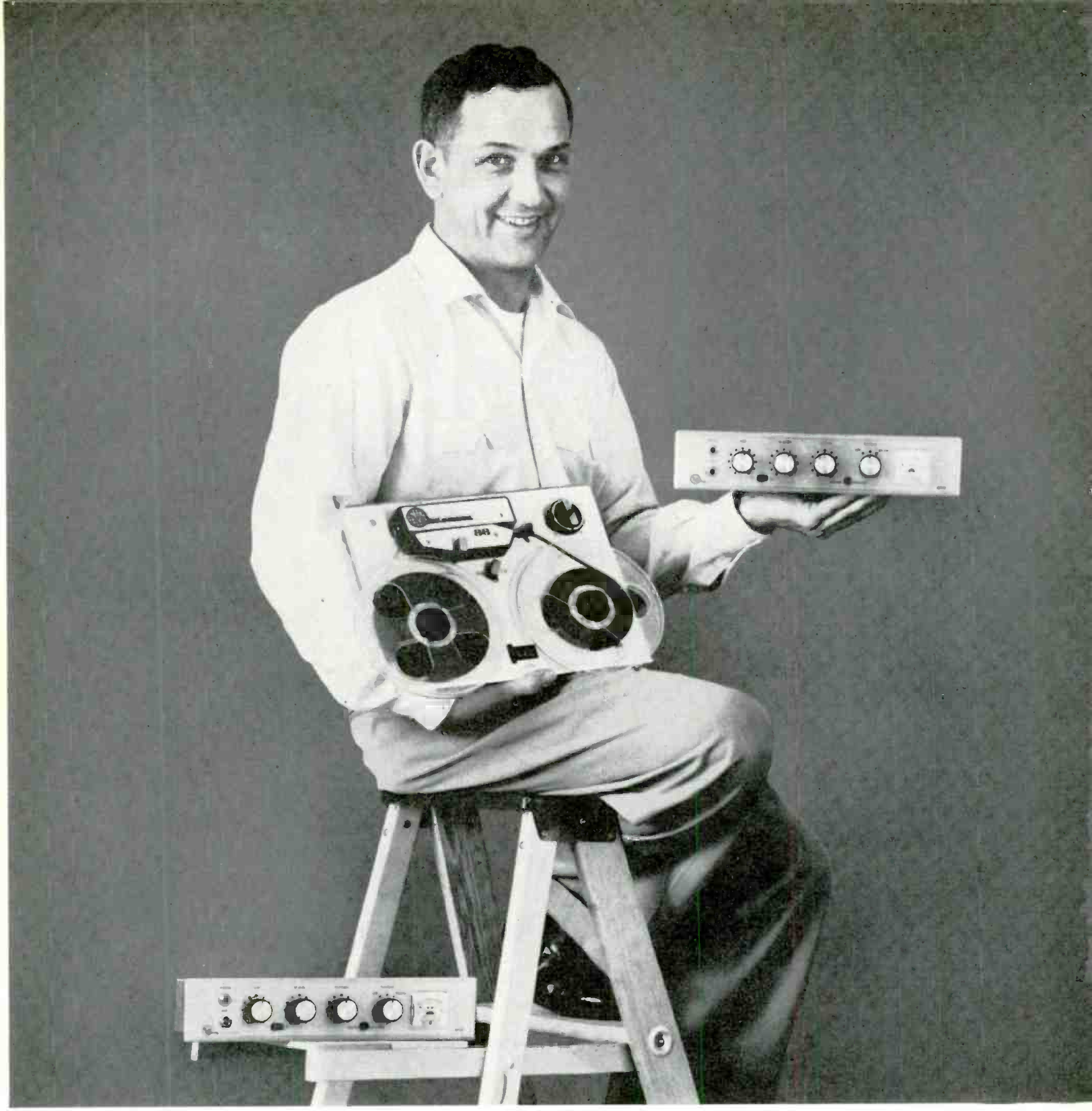
3. Determine F_{m2}, the mean frequency between 500 cycles and 2122 cycles; as stated before, this is most easily done on audio log paper by measuring halfway between these frequencies. F_{m2} is 1030 cycles. Mark F_{m2} as a point on the lower shelf. Place a straightedge at point F_{m2} and turn the straightedge so that you have a line passing through this point and, at the same time, tangent to both curves A-B and C-C. Use this line, D-D, to connect the bass-boost and treble-cut curves.

The final curve, A-C, drawn as a heavy line in Fig. 7, is an extremely close approximation of the RIAA playback equalization curve. If you compare the construction of Fig. 7 with the actual RIAA curve in Fig. 3, you will find that the difference is barely discernible. While it has taken a fair amount of space to describe the construction technique, once it is learned the procedure goes very fast. Only a few minutes are required to draw curves even more complex than the RIAA characteristic.

The foregoing examples have not dealt with curves that rise with frequency, namely bass cut or treble boost. However, the procedures are exactly the same, except that Basic Curves 2 and 2A are used in the process. ▲

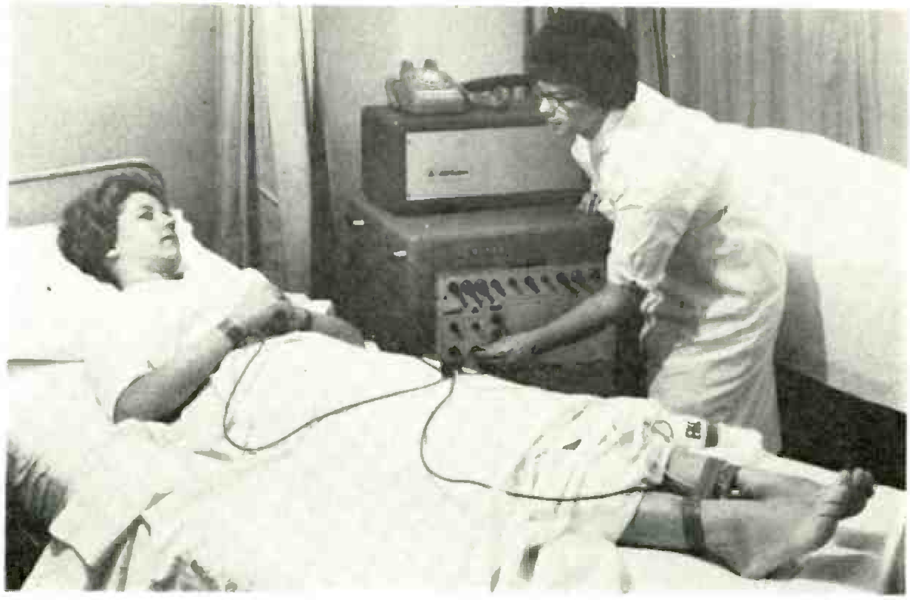
Fig. 7. Construction of the RIAA disc playback curve by means of the graphic method.





ELECTROCARDIOGRAMS RECORDED BY REMOTE CONTROL

Heart signals are transmitted over telephone lines for recording and diagnosis at another location.



Patient at West End Baptist Hospital in Birmingham, Alabama is fitted with sensing devices that pick up heart action. The pattern of action is transmitted electronically by telephone to recording equipment at another hospital for interpretation.

ELECTRONIC transmission of physiological data directly from a patient, along with automatic recording of it in a clinical center elsewhere for immediate interpretation, may soon become an established medical practice.

This is the promise of experiments in Birmingham, Ala. in which, for the first time, "live" electrocardiograms are being "dialed" by telephone from one hospital and charted on a direct-writing oscillograph in another hospital several miles away.

The experiments are being conducted by Dr. True W. Robinson, a clinical pathologist and physiologist of Birmingham's Memorial Institute of Pathology. Collaborating in the tests are the Birmingham Baptist Hospitals, *Minneapolis-Honeywell Regulator Co.*, and *Southern Bell Telephone & Telegraph Co.* Equipment for recording transmitted electrocardiograms is presently available, while adaptive telephone equipment is being developed.

In the tests, electrocardiograms given patients at West End Baptist Hospital were instantly readable on the recorder at Highland Ave. Baptist hospital. This is how the system operates:

Operation of System

At the transmitting end (which could be several thousand miles distant) the minute electrical impulses generated by contraction and relaxation of a patient's heart muscle are sensed by electrodes. These electrical impulses (each about 1 mv. in amplitude) are amplified and fed into a telephone data set where they are converted into signals having a frequency proportional to the magnitude of the voltage. This is done to prevent loss of essential information and to reduce interference in the FM mode of transmission used.

A medical technologist then dials the telephone number of the receiving station and pushes a button on the data set to start transmission of the signals representing the heart pulsations.

At the receiving point, the frequency is automatically converted back to a voltage so that the patient's heart signal can be charted on the recorder.

The multichannel recorder used is the same type that is used extensively for direct readout of missile and other space-vehicle data. The instrument can record from five to eight tracings at one time. Heart tracings, normally a dozen in number, are usually made singly in time sequence.

Dr. Albert E. Casey, director of the Memorial Institute and pathologist of the Baptist Hospitals, said "The knowledge and ability of heart specialists in leading medical centers can now be made available to physicians and their patients in any part of the country and for conferences between groups of medical specialists in different cities." ▲

Four-Channel Audio Mixer

(*Continued from page* 51)

transformer (T_7) was used for this stage, with its center tap grounded. This also provided an unbiased 6.3 volts for use on the meter lights. R_{10} was placed in series with the meter lights to increase their life expectancy since they appeared to be difficult to replace. R_{13} is a standard value used with all vu meters and was furnished with the meter. It decreases the sensitivity of the meter so that 0 vu (100% on the 0-100 scale) is actually at +4 dbm.

Construction

Two separate chassis bases were used on the original version, which made rigidity a problem. One single chassis for both preamp and output stage is preferable and will involve fewer problems during the wiring process. No suitable low-silhouette cabinet was available at the time of construction so both the case and chassis were hand fabricated.

After the chassis and front panel were prepared, the tube sockets, transformers, and jacks were mounted. It is a good idea to wire the filaments by first twisting the leads and then placing them close to the chassis. Next comes the wiring to the meter switch—which wiring should then be laced. The transformer to grid wires are installed using RG/58U cable. Like all grid and potentiometer leads, these should be kept as short as possible and the shields connected to the common ground bus at only one end. Now the terminal boards may be installed next to the preamp stages and their components mounted. Special attention should be given to the negative ground bus. A large bus wire must be run around the stages and grounded to the chassis at only one point to prevent ground loops. The grounded ends of all components associated with each preamplifier stage are connected to the ground bus at one common point. The one exception to this is the grounded end of each potentiometer. The rest of the wiring will follow naturally and should pose no problem.

The power supply was built in a 3" x 4" x 5" chassis box and air circulation is provided at one end by a small vent plug. The wiring is straightforward and nothing is critical. Much of the room is taken up by the two transformers. If any substitutions are made it would be advisable to obtain all parts for the power supply before purchasing the case as, in the author's version at least, there was no room to spare.

Input transformers T_1, T_2, T_3, and T_4 were obtained several years ago from a now-forgotten source. They were advertised as being similar to the *UTC* A-11 and were labeled ADC-24. Since in all probability these particular units are no longer available, your best bet would be the *UTC* A-10, A-11, or similar transformer. These should give an even better low-frequency response than the original version. ▲

Electric Engines for Space

(*Continued from page 28*)

The plasma-pinch engine demonstrated by *Republic Aviation* has a number of advantages. The operating temperature of the engine is low, since the only heating is internal heating of the plasma as it is expelled. This simplifies construction. The specific impulse is variable by changing the fuel rate. Since the engine is, in effect, a series-resonant circuit consisting of the capacitance of the source, the inductance of the leads, capacitors, and plasma, the current is in the form of a damped sinusoid. This results in successive pinches, the frequency depending on the amount of gas and the circuit parameters. Since the more pinches per second, the more thrust, this gives a convenient way of controlling thrust. The entire engine block diagram is shown in Fig. 7.

The electrostatic engine

Highest specific impulse—from 5000 to as high as 100,000 seconds—can be obtained from the electrostatic engine. This mechanism is a first cousin of the electron gun in a TV tube. Instead of electrons, however, it shoots ions. In many practical applications, cesium ions are used, both because they are easy to produce, and because they weigh 240.000 times as much as electrons. Thus for any given exhaust velocity, they produce 240,000 times as much thrust.

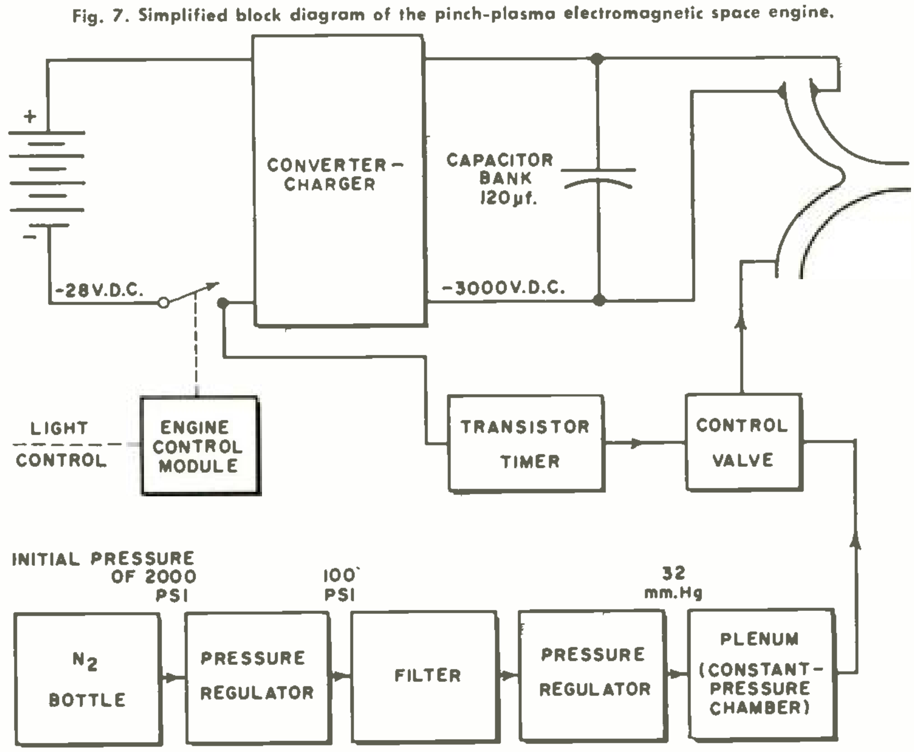
A simple model of an electrostatic engine is shown in Fig. 6. First, the cesium is ionized by moderate heating. The positive ions are attracted to the negative accelerating electrode, then focused by the decelerating electrode. The biggest problem connected with the ion engine is neutralization. If the ions were simply shot from the space ship, a negative charge would rapidly build up on the ship. This charge would soon become so large that it would cause the ion beam to curve around and return to the ship, effectively cancelling out all thrust.

To eliminate this, the ion beam must be neutralized, that is, its electrically positive charge must be destroyed. This is accomplished by re-inserting electrons into the beam after it leaves the focusing electrode. Although this method of neutralization appears to work effectively in vacuum-chamber tests, scientists are not absolutely sure that present methods will prevent a long-term negative charge build up when the unit operates in free space. This is one of the crucial questions to be answered when the engines are flight tested late this year or early in 1963.

Oscillating electron engine

United Aircraft Corporation scientists think they may have eliminated the neutralization problem altogether with an electrostatic engine which operates on a different principle. This device is called the oscillating electron engine. Electrons are emitted from the cathode, are then attracted by five positively charged anode rings, and travel down toward the open end of the tube. Here, they come under the influence of the grounded ring which forms the last segment of the tube and is at the same potential as the cathode. This ring repels the electrons back toward the cathode. When they reach the cathode on the return trip, they are again repelled, and start back through the tube again. Trapped in what engineers call a potential "well", the electrons oscillate axially in the tube, shooting back and forth from cathode to ring. Some of the electrons are attracted and captured by the positive rings, but most continue to oscillate. At the same time, current

Fig. 7. Simplified block diagram of the pinch-plasma electromagnetic space engine.



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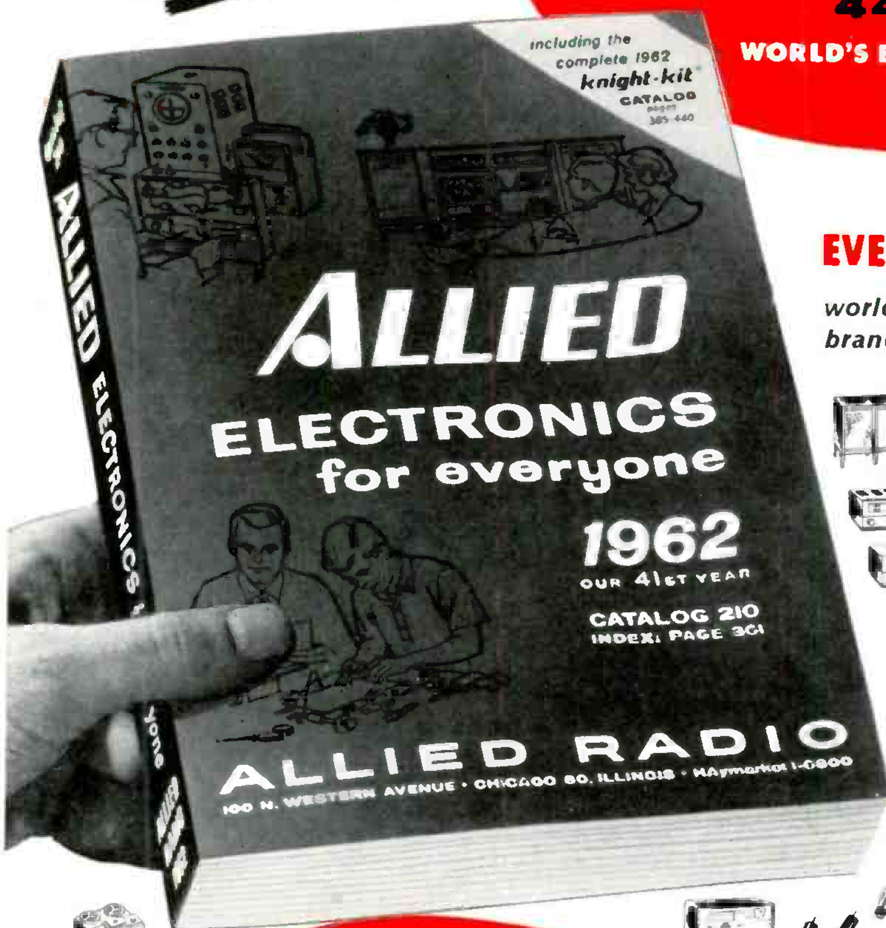

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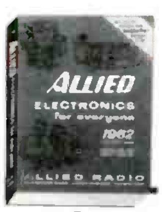

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An electrically neutral working fluid —in gaseous form—is introduced into the tube at low pressure. Bombarded by the oscillating electrons, the propellant molecules lose an electron and become positively charged ions. The electrons knocked loose become trapped and they begin to oscillate with the other electrons.

An electrostatic potential well whose profile has been shaped by altering the voltages on different electrodes, acts as a potential "hill" for the ions, accelerating them in a directed beam out of the tube. *United Aircraft* researchers say that since many electrons are also available inside the tube, copious quantities of them are drawn into the ion beam, creating an electrically neutral plasma exhaust. The exhaust velocity can be controlled by altering the voltages on the electrodes and by using propellants of various molecular weights. If the engine works in space tests as well as it has in the laboratory, this may settle the question of beam neutralization for good.

Other advantages, too

The oscillating electron engine is not critical so far as fuels go, either. Researchers have already operated it on such widely diverse propellants as mercury, helium, argon, neon, hydrogen, nitrogen, krypton, and carbon dioxide. In fact, any material which can be vaporized at a temperature below the melting point of the container can be used. The prototype models have even been run on hot breath (trapped in a balloon).

The upcoming flight tests

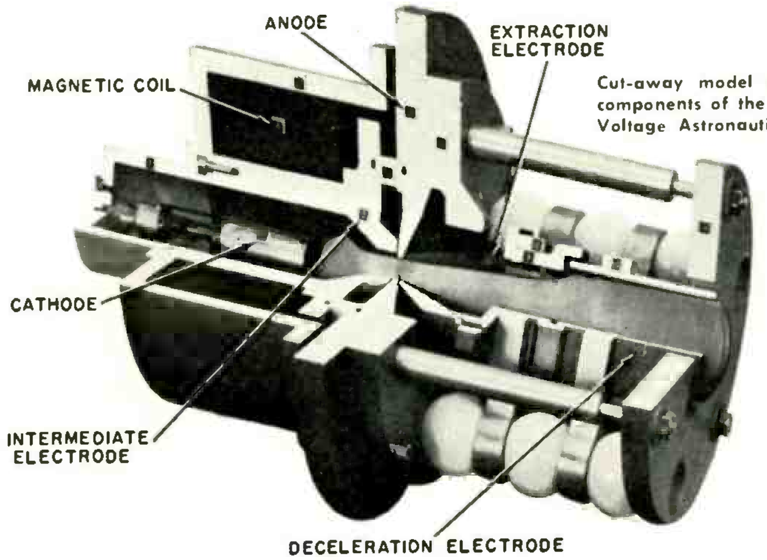
NASA is planning a program of at least ten Scout rockets to test as many of the new electric engines as seem promising. When SERT—Space Electric Rocket Test—gets underway a year or less from now, at least one rocket shot every three months will take aloft at least two experimental engines at a time. As presently envisioned, the rocket will be hurled skyward and put into a 100-rpm spin. Then one of the electric engines, oriented to oppose the spin, will be turned on and the time required to slow the rocket down to 70 rpm will be measured. At that point, Engine No. 1 will be shut off and Engine No. 2, aimed to accelerate the spin, will be turned on. Now, the time required to bring the rocket back up to a spin rate will be clocked.

Electrical space engines will undoubtedly go to work first helping to keep satellites in exact orbits, or changing them from one orbit to another. Our proposed 22,000-mile communications satellite, for example, could be shot into a low orbit by chemical means—we've got the rockets to do this now—then slowly nudged into its 22,000-mile circuit with an electric engine. Once there, its position could be corrected from time to time as it tended to drift. It is thought that engines already operating in prototype would be suitable for this kind of duty. They could be run from batteries rechargeable by solar cells, and thus operate intermittently over a period of years.

Nuclear power

Electric space drives for deep space journeys will have to await the development of a more practical source of electrical power. Engines with thrusts in the range of tens or even hundreds of pounds are theoretically possible, but might require on the order of 50 kw. of power for every pound of thrust generated. This kind of power is not yet available from any source light and compact enough to fit into a rocket. Nuclear power would seem to be the answer here. Power from fusion—if and when it is developed—would probably be even better suited.

When such electric plants are developed, then electric space propulsion, with its ease of control and tremendous propellant economy, will drive our space ships and probes on their journeys throughout the solar system, and perhaps some day, even beyond. ▲



Cut-away model showing basic components of the Goodrich-High Voltage Astronautics ion engine.

25TH ANNIVERSARY
Parts Distributors Show May 21-24 in Chicago

Four-day meet adds new features for the industrial distributor.

THE 1962 Electronic Parts Distributors Show and Conference, to be held May 21-24 at the Conrad Hilton Hotel in Chicago, will mark the 25th anniversary of one of the electronic industry's major national events.

As in all past years, the Show will attract hundreds of manufacturer-exhibitors and thousands of other visitors representing industry, electronic distributing firms, and sales representatives.

The format of the Show has remained basically the same throughout its history, but each year improvements and innovations have provided new interest, continuously making it more useful to those in attendance. It is the only trade show in the entire industry planned and conducted exclusively for electronics distributors.

A new program and new exhibition facilities will make 1962 the year of the "Big Change." The Show has been extended to four days, from three, with Executive Conference Day as a new feature on Monday, May 21, the first day of the Show. This feature has been added to the program to fulfill an increasing need for a time and place at which manufacturers of electronic parts, accessories, high-fidelity and sound equipment, whose products are marketed nationally through distributors, can meet face to face with their distributors to discuss matters of mutual interest.

Another important activity of the Show and Conference is the Industrial Conference Section, introduced with great success at the 1961 Show. Twenty-one thousand square feet of floor space will be used for this section that is designed for that ever-growing segment of the industry whose manufacturers sell their products through industrial electronics parts distributors. The special needs of both manufacturers and distributors of industrial products will be served by providing private booths where they can discuss profit pictures and distribution patterns, exchange information about industrial marketing, and display the newest industrial electronic products on the market.

At the 1962 banquet, which will be held on Tuesday, May 22nd, past directors of the Show Corporation will be honored guests. It is expected that some 94 of them will celebrate the 25th anniversary of the Show and will be joined by approximately 2000 others associated with the industry as manufacturers, dealers, and distributors. ▲

SUPERCONDUCTING MAGNET SYSTEM

A cryogenic magnet system, able to develop intense fields at liquid helium temperatures, is marketed.

A LOW-TEMPERATURE magnet system, capable of developing an intense field of 50,000 gauss at a temperature of 4 degrees above absolute zero, is expected to open a new area of high-field magnet research. The new system, marketed by *Westinghouse,* will be of interest to industrial, governmental, and academic laboratories engaged in research in cryogenics, superconductivity, magnetics, and plasmas.

The superconducting system consists of a coil and its support, a special power supply, gaussmeter, Dewar assembly, helium liquid level indicator, and helium transfer tube.

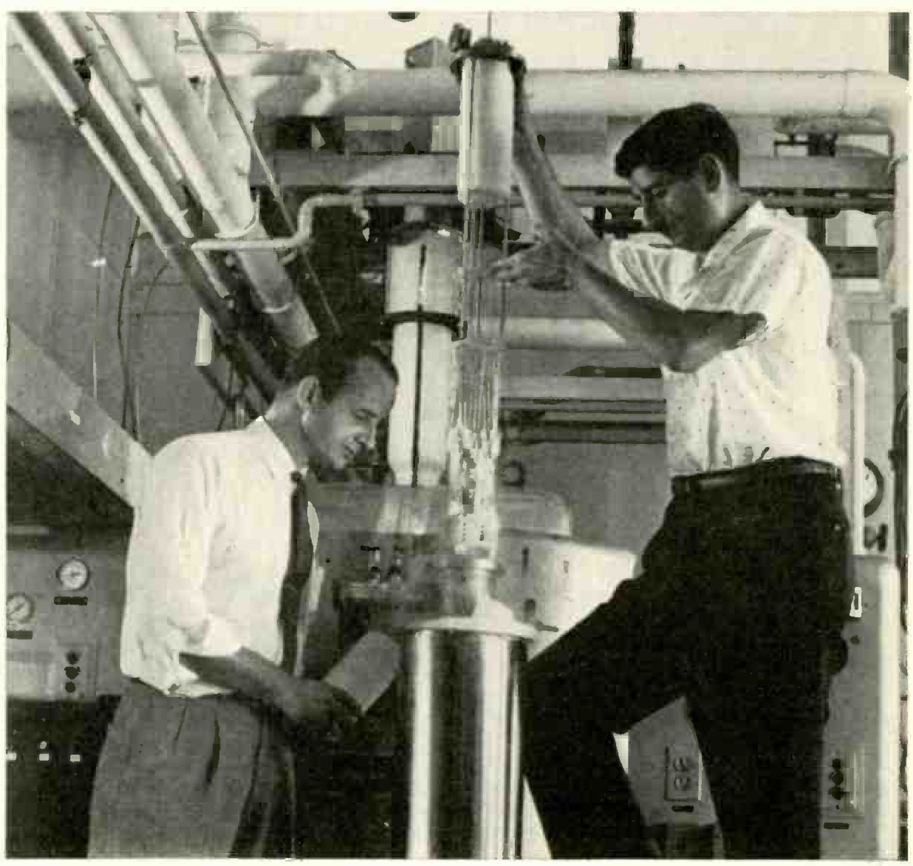
The superconducting magnet contains two miles of wire about the diameter of a sewing thread. The wire is a niobium-zirconium alloy that has been fabricated by means of special metal processing techniques. A solenoid of this wire with an over-all size of about 3 inches in length and 3 inches in diameter produces the 50,000-gauss magnetic field within the ½-inch inside diameter.

In use, the coil is immersed in a cold-retaining bottle (Dewar) filled with liquid helium which keeps it at a temperature near 269 degrees C below zero. The energy required to cool the coil is only a small fraction of that needed to create a comparable magnetic field with a standard electromagnet. Essentially, the magnet produces almost all of its supermagnetism "for free."

A transistorized power supply furnishes constant current, low ripple d.c. power for use with the superconducting magnetic coil. The portable unit is designed for less than 0.1 per-cent regulation from no load to full load with an input voltage variation from 105 to 125 volts a.c.

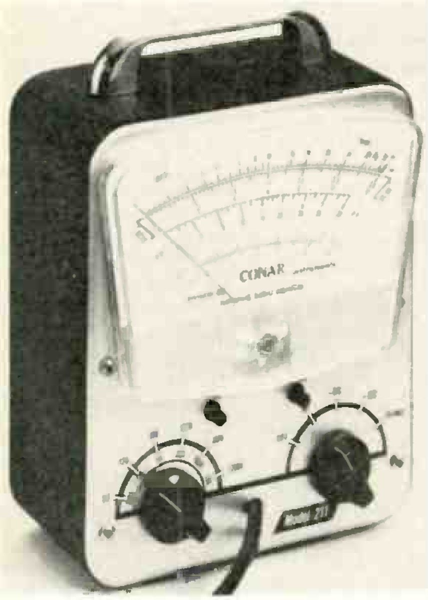
Unique protective features are incorporated to prevent damage to the power supply or to the superconducting magnet. For example, if the load current inceases at a rate greater than 4 amperes per second, or if the output voltage increases at a rate greater than 0.1 volt per second, the power output current is reduced to zero. Furthermore, provision is made to reduce the output current to zero when the liquid helium reaches a predetermined low level. A dumping circuit is provided in the power supply to dissipate a portion of the energy stored in the magnet in the event it goes into normal conduction range. In addition, a thermal detector and a time-delay relay are used to prevent internal damage to the power supply. ▲

The magnet enclosed in the small, round perforated case just above the metal cylinder contains two miles of threadlike wire which loses all electrical resistance at temperatures near absolute zero. The tiny magnet has twice the strength of the massive iron-core magnet behind it when run to saturation of the iron that is used.



Product Test Report

(*Continued from page 22*)



is no 1-megohm isolating resistor in the test prod; instead, a special low-C coax cable is used that makes this resistor unnecessary. We measured the capacitance of this lead and found that it was only 42 $\mu\mu f$. When we later tried using the meter for direct r.f. measurements, we found that its low loading permitted it to be used well up into the r.f. range.

The large 6-inch meter with its simple, uncluttered dial makes it easy to take accurate readings with a minimum of eye-strain. The meter has a 1-ma. movement rather than the usual 200-μa. value, so that it should be rugged and hard to damage. A look at the photo above shows that there are no knobs on the knurled, plastic shafts on the pots used for zero set and ohms adjustment. Once these controls were set, we found the long-time stability as well as the range-to-range stability so good that it was not necessary to touch these at all.

The meter has six d.c. and a.c. ranges (from 3 to 1200 v.) and six resistance ranges (from 10 ohms to 10 megohms, mid-scale). The polarity of the instrument can be reversed if required. A special peak-to-peak scale is also included. The circuit itself is simple and conventional. A 12BH7 twin-triode is employed in the usual balanced bridge arrangement with the 0-1 ma. meter connected between the two cathodes. One diode section of a 6X4 is used as a simple peak rectifier for a.c. signals. Resistance is measured by use of a 1½-volt flashlight battery, a voltage divider, and the voltmeter circuitry. One per-cent resistors are used in the d.c. and a.c. dividers, while 5% resistors are used for ohms measurements. A half-wave selenium rectifier supplies a measured 80 volts to the twin-triode. Built-in calibration pots are provided for d.c. (using the 1½-volt flashlight cell) and for a.c. zero adjust. We were a little surprised that there was no calibration pot for setting up the a.c. ranges for some known voltage. Most v.t.v.m.'s use the line voltage for this purpose. In this case, such an adjustment was found to be completely unnecessary and a.c. readings were quite accurate without it.

The first test we made was of the d.c. accuracy of the instrument. We took several voltage readings (using a variable power supply) on each range and compared our readings with those obtained on a lab-type v.o.m. All readings fell between −1% and +2% of full scale. The same procedure was followed in checking a.c. accuracy. We found all readings to be between −½% and +3%. The accuracy was thus seen to be well within the limits needed for service work. What is more, there was excellent agreement of readings of the same voltage taken on several scales. Input impedance of the meter is 12.2 megohms on d.c. and close to 1.5 megohms on a.c. We measured this latter value at 1000 cps on the three lower ranges.

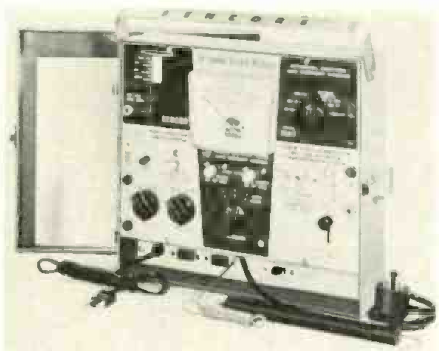
Next, we measured the a.c. frequency response of the meter to see how good a job it could do in audio work. At the low end of the audio spectrum, response was found to be down only ½ db at 50 cps and 1 db at 20 cps. At the high end, response was perfectly flat out well beyond the top limit of the audio range. As a matter of fact, the meter was still absolutely flat out to 6 mc. before it started to show a rise in reading. We hit a peak of 6 db at 9 mc. before the reading started to roll off. This rising response in the r.f. range is typical of many v.t.v.m.'s we have checked; it is probably due to the shunt capacitance across the multiplier resistors, forming a high-frequency peaking network that boosts response at higher frequencies. Just out of curiosity we continued still higher in frequency. We found another peak at about 18 mc., then a gradual roll-off, but we were still reading r.f. directly on the meter up to about 30 mc. We would have liked to see a db scale on the instrument since it is so well suited for audio measurements, except for low-level values.

Finally, the resistance ranges were checked by measuring a number of known 1% and 5% resistors. All measurements were very close except for those on the lowest resistance range. We wondered why a meter that was so accurate on all its other functions should read low on the lowest resistance range. We checked the 1½-volt battery while switched to the lowest resistance range and we found that it read only 0.4 volt with the test prods shorted for a while. Substitution of a fresh flashlight cell brought all readings up to their proper values. The cell, by the way, is soldered to its leads; it would have been a little more convenient to have a battery holder with built-in leads.

In summary, the Model 211 is a simple, but accurate and highly useful piece of test equipment that will give plenty of satisfactory use on the service bench. It is available for $31.95 in kit form. . . . . E. W.

Sencore SS117 Sweep-Circuit Analyzer

For copy of manufacturer's brochure, circle No. 59 on coupon (page 108).



FEW TV technicians have never suffered the experience of replacing a "defective" flyback transformer, yoke, or other sweep component, only to find that they were on the wrong trail. Horizontal sync, oscillator, sweep, and high-voltage circuits are so closely interrelated that narrow fault localization and reliable checking of suspect components are not easy to manage. Some of these difficulties apply to the vertical circuits too.

Aware of the problems, the designer of Sencore's SS117 Sweep-Circuit Analyzer has packed an impressive number of direct, dynamic tests into a single unit, many of which can be made without removing the TV chassis from its cabinet, let alone ripping the chassis apart. Facilities include substitute vertical and horizontal saw-tooth signals, variable in amplitude. The former is line-synchronized; the latter has an external frequency adjustment and can be locked to pulses from the set.

There is a "universal" substitute for the horizontal deflection coils (variable from 5 to 40 millihenrys), a dynamic check for flyback transformers operating in their own circuits, facilities for metering voltages and currents in the analyzer or receiver (including h.v., with a range-extending probe provided), a plug-in adapter for monitoring the horizontal-output tube (including a set-up switch and miniature roll chart for different types), and a substitute drive signal for checking vertical yoke coils. Further, most facilities have been so arranged or isolated that more than one can be in use simultaneously.

A description of the complete range of sync and sweep circuit tests would be quite lengthy: in addition to the instruction manual, *Sencore* packs a long-playing record covering all essential procedures and urges the user to hear it more than once. However, we can give some idea. An adapter at the end of a cable plugs into the socket for the horizontal-output tube on the chassis, with the tube itself being plugged into the adapter. This facilitates separate monitoring of cathode and screen currents. To check required drive signal, the TV horizontal oscillator can be disabled (as by withdrawing the tube) and the analyzer's saw-tooth output can be applied through the adapter and metered. To check sync, pulses from the set can be applied to the analyzer's generator in this same set-up.

If the receiver's horizontal yoke is disconnected, the internal substitute coil is readily connected in its place and adjusted for best match. A pick-up coil on the latter feeds the analyzer's meter through a rectifier. With one meter scale calibrated directly in degrees of deflection, the presence or absence of adequate output from the flyback system can thus be checked.

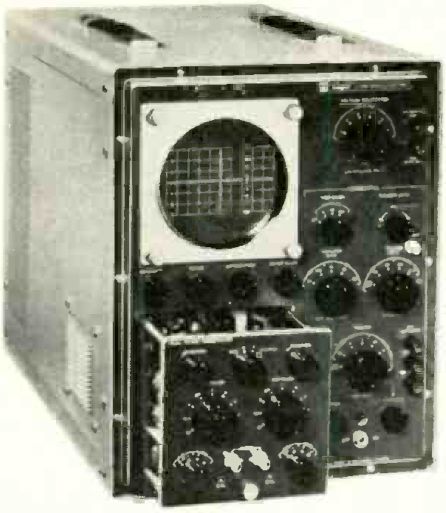
As noted earlier, we have merely suggested some of the things the SS117 can do. Aside from fault-finding, it can be used for accurate setting of circuit adjustments. For example, adjustment of a linearity coil for best linearity and correct boost voltage is simple while the cathode current of the output tube is being monitored.

Our own use tests indicated that the instrument does all the things claimed for it and meets its specifications honestly. For example, although correct sweep linearity would not be essential, the vertical and horizontal saw-tooth outputs maintained surprisingly good waveshape at any amplitude and, in the case of the latter, at any frequency setting.

The only criticism that could be leveled against the SS117, justifiably or not, is that it may take quite a bit of time to learn how to use it quickly. However, this is inevitably true of any complicated instrument that provides such a range of facilities. How many technicians have become completely adept with the oscilloscope after one session of use? The prospective buyer would have to weigh this factor against his present ability to tackle sync and sweep problems. Once he has bought the unit, he should make sure to employ it wherever possible, instead of letting it gather dust while he avoids the bother of learning the new techniques it entails. He will doubtless find that it has paid for itself by the time he has become fully adept in its use. A troubleshooting chart (symptom vs test) in the manual should help matters considerably. Dealer net price is $89.50 .... E. W.

"Knight-Kit" Laboratory Oscilloscope

For copy of manufacturer's brochure, circle No. 60 on coupon (page 108).



THE modern lab scope is a far cry from the early scopes that just barely managed to show a waveform of the applied signal. The modern instrument will not only display the waveform accurately, but it frequently has facilities built in to measure the peak-to-peak amplitude as well as the time duration of that waveform. What is more, since the sweep is usually a triggered one, it is not necessary to search around with both coarse and fine sweep-frequency controls until a couple of cycles of pattern appear on the screen and then adjust the sync control to keep the pattern steady. Instead, all that happens when you change sweep rates is that you simply see a different number of cycles on a stationary waveform pattern.

The "Knight-Kit" lab scope (Catalogue No. 83 YZ 945) is a full-fledged laboratory instrument with all the above features built in and at a price less than half that of comparable scopes—because it is a kit. The circuits and the kit as a whole have been superbly engineered and it appears to us that no compromises in quality or features were made to accommodate the kit form. Although we did not assemble the kit ourselves, it is obvious that this is not a unit that can be put together in a few evenings spare time. As a matter of fact, the 128-page construction manual has been divided into five separate sections so that a number of technicians can work on the assembly at the same time. To give an idea of how elaborate the instrument is, the basic scope has some 38 tubes, 17 semiconductor diodes, 20 neon lamps, 278 resistors, and 109 capacitors. The preamp may have as many as 10 more tubes to wire up along with an appropriate number of resistors, capacitors, and switches. True, many printed circuit and component boards are included, but each of the parts must be mounted and soldered.

The scope which we checked had a plug-in dual-trace preamp that permits two separate signals to be displayed at once on the CRT.

Other preamps are available, also in kit form, for plugging into the basic scope. The instrument, when used with the dual-trace preamp, has a bandwidth from d.c. to 10 mc., a maximum sensitivity of 50 mv. (peak-to-peak)/cm., and a rise time of 40 nanoseconds. Waveforms are displayed on a 5-inch, flat-face, post-accelerator CRT with an accelerating potential of about 5 kv.

There are 30 calibrated sweep ranges with a wide choice of triggering-signal sources and triggering level. This latter feature allows the sweep to be triggered at either polarity of signal and at any point on the waveform. Hence, the display can be made to show a waveform that appears to start at any part of the cycle. It is also possible to expand the sweep horizontally either 5 times or 20 times so that a very small part of a waveform can be examined. This is especially useful if you want to study the rise time or decay time of a square-wave signal or a short pulse. Push-pull amplification is used throughout for balanced deflection.

Very extensive use is made of voltage regulation so that the scope is not affected by line-voltage changes. For example, there are no less than four separate rectifier systems in the low-voltage supply (three of these are full-wave bridges), and each of these has four or five triode sections as control and regulator tubes. Even the r.f.-oscillator high-voltage supply with its two separate rectifier systems uses a two-stage feedback regulator. Just out of curiosity, we switched on and off a 1100-watt load in the same a.c. line that was connected to the scope. Although this caused the scope's a.c. voltage to change abruptly by 6 volts (118 v. to 112 v.), both the amplitude of the waveform being watched and the sweep speed remained rock-steady. The only effect was a very slight change in intensity.

Built into the instrument is a 1000-cps square-wave voltage calibrator that furnishes from 10 mv. to 50 v. (p-p) ± 1%, in 24 fixed steps. This facility, when used along with the calibrated vertical attenuator of the scope, allows the amplitude of any waveform to be measured accurately. Also built-in is a 100-kc. crystal oscillator and a series of multivibrators that provide intensity-modulated marker pips for the sweep at 10-μsec., 100-μsec., and 1000-μsec. intervals. This feature allows the sweep speed to be adjusted very accurately (± 1%) so that the time duration, and hence the frequency, of an observed waveform can be measured directly.

About the greatest compliment that can be paid to such an instrument with its large number of operating controls and internal trimmers and adjustments is to say that everything does just what it is supposed to. All the controls work properly and there is excellent range-to-range accuracy of the vertical and horizontal attenuators, and the sweep magnifier control. There is absolutely no hum deflection of the trace, even with the gain controls wide open. Also, sweep linearity is very good as evidenced by the perfectly equal spacings of the crystal-controlled time markers along the sweep.

To check the amplitude calibration accuracy, we applied a wide range of input signals to the scope ranging from about 1 v. (p-p) to over 300 v. (p-p), while monitoring these signals with a lab voltmeter. (The higher voltages were applied through a 10:1 low-C probe.) Although the scope screen could not be read as closely as the meter scales, most of the readings we checked were right on the button with a couple of the readings being, at the very worst, no more than 3% low. We also applied a number of known frequencies to the scope and, by the use of the calibrated sweep, measured their frequencies. Again there was very good agreement between the scope measurements and the settings of our signal generators.

While using the crystal-controlled time markers, we ran a lead from the scope near the antenna of our communications receiver. Although we could hear a strong pulse buzz every 100 kc. well up into the higher megacycles (including right on top of WWV's carrier at 5 and 10 mc.), the bandwidth of the 100-kc. signal was fairly broad so that it was impossible to check the calibration accuracy by making a zero-beat adjustment or to identify which harmonic we were hearing.

Although we had no means of checking the high-frequency response of the scope accurately, we did connect an r.f. signal generator to it to see how far up we could see evidence of an r.f. signal. We were still seeing some r.f. at frequencies as high as 30 mc., although above 10 mc. it was practically impossible to sync the pattern. The scope seemed to show a smooth, gradual roll-off from 10 mc. to 30 mc., and we are certainly willing to take the manufacturer's rating of d.c. to 10 mc. (within 3 db) as being correct. We had no problems at all with very low frequency audio signals or even d.c.

One minor point that confused us a little was the polarity markings on the input-selector switches on the preamp. These were marked "A.c. +," "A.c. —," "D.c. +," and "D.c. —." We would have liked to have seen a positive-going signal applied with the switches in the "+" positions producing an *upward* deflection on the CRT. However, in order to obtain an upward deflection with a positive signal, these switches had to be in the "—" positions.

In summary, we would say that the instrument is a professional oscilloscope in every sense of the word. It should be extremely useful in laboratories and in industry where a scope of this caliber is required. The price of the lab-scope kit is $395.00, of the dual-trace preamp kit is $79.95, and of the low-capacity probe kit is $16.50. A differential high-gain plug-in preamp kit is also available, as well as blank preamp chassis to permit the designer to build his own. .................................E.W.

ELECTRONIC VIBRATO

By F. H. CALVERT

Construction of a vibrato circuit that can be added to an amplifier to be used with musical instruments.

THIS SIMPLE addition to any existing amplifier will make such an amplifier suitable for use with musical instruments.

Basically, the circuit is a phase-shift oscillator, the output of which is capacitively coupled to the plate of the first audio stage of the amplifier. The generated sine wave adds to or subtracts from the plate voltage, depending on the phase angle of the generated cycle. The frequency of oscillation is approximately 8 cps and may be conveniently raised or lowered, if so desired, by changing the value of any one of the 2-megohm resistors in the network. (See Fig. 1.)

Plate and heater voltages can be obtained from the existing power supply in any straight a.c. amplifier. If an a.c.-d.c. type amplifier is used, the plate voltage may be obtained from it, but heater requirements are met by using an auxiliary transformer (117-volt input, 6.3-volt @ .3 amp. output). Plate current is on the order of a few milliamperes.

The amplitude of the vibrato is adjusted for best sound with the 2-megohm potentiometer. When vibrato is not desired, the control is turned to zero.

The small amount of space required by this circuit makes it possible to build the unit right on the chassis of the existing amplifier. Use shielded lead wire to and from the vibrato amplitude control.

A 6SC7 tube was chosen as there were already two in the amplifier with which the circuit was used. However, a 6SL7GT can be substituted for it directly as the pin connections for the triode section shown are the same. Any ordinary high-mu triode can be used, providing the necessary socket and pin changes are made. ▲

Fig. 1. Circuit diagram of the phase-shift oscillator that provides vibrato.

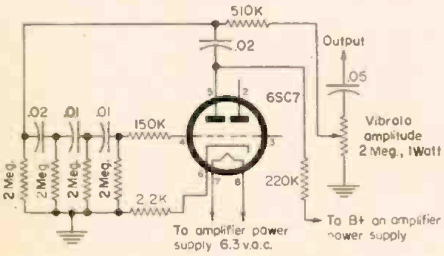
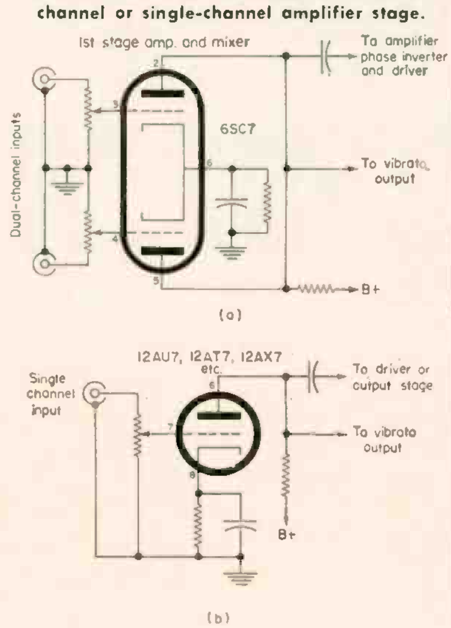


Fig. 2. Circuit arrangement showing how vibrato circuit is connected to a dual-channel or single-channel amplifier stage.



Transistorized Transmitter
(*Continued from page* 52)

class-C amplifier which eliminates the need for neutralization. Resistor R_2 provides base bias for the stage, while the base is grounded (for signal) *via* capacitor C_1. The output signal is developed across choke RFC_1 and coupled through capacitor C_2 to the pi-network tuned circuit consisting of capacitors C_3 and C_4 and coil L_3. A pi network was selected for its harmonic rejection rather than its antenna-matching abilities, however, capacitor C_4 may be made variable so that the unit will better match an existing antenna.

Modulation is achieved in a modified Heising manner, with mixing occurring across resistor R_3. Capacitor C_5 is placed across the battery to keep its a.c. internal resistance low, even though its d.c. resistance becomes high with age.

Construction

Each transmitter is housed in an aluminum box measuring 3¼" x 2⅛" x 1⅝". The chassis or wiring board is a piece of cloth-base phenolic measuring about 1½" x 3", with hollow brass leather eyelets as circuit tie-points. A binding post is used for the antenna terminal, while the audio input is supplied through a phone jack. The leads for the battery are brought out through a small grommet in the end of the case.

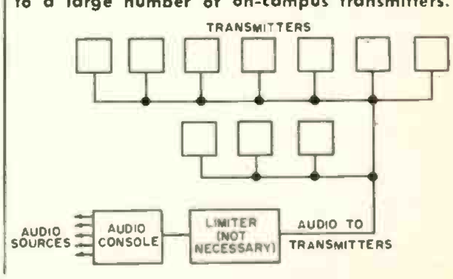
Operation

This unit is intended for battery operation, using an *Eveready* 744 6-volt battery. This is usually sufficient for about a year of operation. Since the current drain is so low, the unit is left on continuously.

Once power is applied to the unit, the oscillator tank coil is tuned to maximum output using an oscilloscope as an indicator. The unit is then placed in location, connected to the antenna and audio lines, and the output tuned for maximum signal strength, using a portable receiver.

Since the device falls under rules concerning limited-radiation devices, care must be taken to insure that the field strength does not exceed 15 μv.-per-meter at a distance of 234 feet (for 670 kc.) from the radiating device. This may be taken to mean "from the antenna," which may be a length of wire running around the side of the building in which the transmitter is placed. (See FCC Rules and Regulations, Paragraphs 15-2 to 15-7.) ▲

Fig. 2. The same audio signal is applied to a large number of on-campus transmitters.



Servicing Diathermy Gear

(*Continued from page* 43)

tioning, since damage can result from overheating.

Intermittent operation can be detected by tapping tubes with a wooden pencil or similar object. Failure of any section of the unit may result in a decrease or total lack of r.f. energy at the output. This can be detected by the absence of warmth when the unit is in operation, but it is more convenient to use a neon test lamp for detection. The neon lamp will glow when r.f. energy is present.

It is a good rule never to change the setting of tuning capacitors until all other sources of trouble have been investigated. Retuning may become necessary, however, when a tube is replaced, owing to differences in interelectrode capacitance. When the type 311CH tube in the r.f. amplifier circuit (Fig. 3) is replaced, for instance, it may be necessary to neutralize this stage again by adjusting the neutralizing capacitor and the tank trimmer.

In the *Raytheon* unit (Fig. 4), insufficient heat when the unit appears otherwise to be operating normally usually indicates a defective magnetron tube. Before replacing the magnetron, however, it is well to examine the 500-ohm resistor, R_3, in series with the anode. If it appears blistered, or if an ohmmeter check reveals that it is open, it must be replaced. Failure of the magnetron can throw an excessive load on this resistor, causing it to fail before a fuse can blow.

Most units have a time-delay relay (see component marked *TDR* in Fig. 4) to keep high voltage off the tube anodes until their filaments have had time to heat, thus prolonging the life of the tubes. Delays up to 5 minutes are provided, and, where adjustable delays are used, the manufacturer's recommendation should be followed. About 3 minutes is normally ample.

Interference

Frequencies on which diathermy equipment may be operated and frequency tolerances are specified by the Federal Communications Commission. Spurious and harmonic radiations on other frequencies must not exceed 25 microvolts per meter at a distance of 1000 feet or more from the diathermy equipment.

At one time, interference by diathermy machines with other services was a serious problem. At the present time, however, the FCC reports that with few exceptions the equipment responsible for interference was manufactured prior to July 1, 1947, and thus does not conform to present standards.

A station license is not required for the operation of medical diathermy equipment on the assigned frequencies. Type approval is granted by the FCC and regular renewal is not required, although the Commission may require renewal if it has reason to believe that a particular unit may be the source of interference to radio communication. ▲

A ROUTINE JOB

By MILTON CRANDALL

IT STARTED out as an ordinary day, but it wasn't long before the phone rang and I had to go to work.

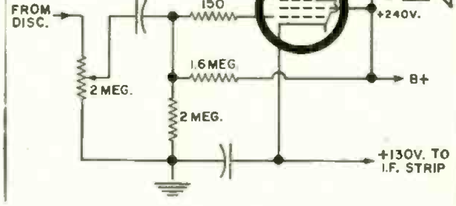
"The picture's pretty good," he said, "but I have to keep the sound too loud to get a picture." "What did you say?", I asked. This was a new one. "Yeah," he said, "I don't get any picture unless I turn the sound up so loud it wakes the neighbors."

The set was soon glaring malevolently at me with its one big eye. Sure enough, it showed a raster, more-or-less normal sound, and not one trace of video. When you turned the sound up, a dim, washed-out picture began to appear. At full volume the picture was there in all its glory. What do *you* think the trouble was? It was an *Admiral* 17XP3 chassis, and the defective component appears in the partial schematic below.

This trouble was unusual in that it is one of the few that can be nailed down to one specific component with nothing but the symptoms, and a bit of reasoning.

Let's look at the schematic. The most significant relationship between sound and video in this and many similar sets is the use of the sound output tube as a dropping resistor in the plate supply to the i.f. strip. This is a class A amplifier; its plate current is supposed to stay about the same whether the stage is struggling with a massive signal or sitting in silence. It's not working that way *this* time, though. A second clue emerged. The set didn't care about the actual volume of the sound; it was the volume control *setting* that made the difference. Here we can nail down the trouble to one component. If the signal strength doesn't affect the operation of that output stage, but the volume control setting does, then the volume control setting is what determines the d.c. operating point of the stage. If it were cut off, we'd have no plate voltage for the i.f. strip, and therefore no picture. "But that can't be." I said to myself. "C_{212} provides d.c. isolation between that grid and the rest of the set." "Not if it's leaky," said a small voice, and sure enough, it was.

The customer wasn't impressed when I made no tests, but just snipped out and replaced one component. After all, I was supposed to know which one, wasn't I? That's what he was paying me for! ▲



MATH PUZZLERS

HOW ABOUT trying your hand at solving some of the "brain teasers" given below. Every one of them will yield to reasoning and, in some cases, pencil and paper. Check your answers on page 106.

1. A forgetful physicist forgot his watch one day and asked an E.E. on the staff what time it was. The E.E. looked at his watch and said: "The hour, minute, and sweep second hands are as close to trisecting the face as they ever come. This happens only twice in every 12 hours, but since you probably haven't forgotten whether you ate lunch, you should be able to calculate the time." What time was it to the nearest second?

2. A new kind of atom smasher is to be composed of two tangents and a circular arc which is concave towards the point of intersection of the two tangents. Each tangent and the arc of the circle is 1 mile long. What is the radius of the circle?

3. When I am as old as my father is now, I shall be five times as old as my son is now. By then my son will be eight years older than I am now. The combined ages of my father and myself are 100 years. How old is my son?

4. A prisoner is given 10 white balls, 10 black balls, and two boxes. He is told that an executioner will draw one ball from one of the two boxes. If it is white, the prisoner will go free; if it is black, he will die. How should the prisoner arrange the balls in the boxes to give himself the best chance for survival?

5. One of the largest known primes is $2^{3217}-1$. Assume that it requires a human being a year to calculate each digit of this number. Who, if anyone, would have been capable of completing the job?

6. A bricklayer has 8 bricks. Seven of the bricks weigh the same amount and 1 is a little heavier than the others. If the man has a balance scale how can he find the heaviest brick in only two weighings?

7. A clock hangs on the wall of an Early Warning Display and Control Center. The wall is 71 feet, 9 inches long and 10 feet, 4 inches high. While waiting for the waning crescent moon to rise, we noticed that the hands of the clock were pointing in opposite directions and were parallel to one of the diagonals of the wall. What was the exact time?

8. The sum of the digits on the odometer in my car (which reads up to 99999.9 miles) has never been higher than it is now, but it was the same 900 miles ago. How many miles must I drive before it is higher than it is now?

The above puzzlers are published through the courtesy of *Litton Industries,* Beverly Hills, California and are eight of thirty-one problems included in the booklet "Problematical Recreations" which they will supply to any of our readers without charge on direct request. ▲

Mac's Electronics Service

(*Continued from page* 44)

"The first 1500-hour run is performed with the tubes that come in the receiver. These are then removed and *Sylvania* tubes used for the next and all subsequent runs. Each receiver is used for between four and seven life-test runs. Between 180 and 250 receivers are operating in these tests at all times, and a total of 1865 television sets of many different makes and models had been used in the program by the end of 1961."

"Why are the same sets used for more than two runs necessary to compare performance of original tubes with *Sylvania* tubes?"

"To determine if the reliability of tubes themselves is improving. When the same receiver is tested with sets of tubes manufactured in different periods of time, tube reliability, free of any influence of receiver design, can be evaluated."

"You mean receiver design influences tube life?"

"And how! For example, tests of two different makes of TV receivers having essentially the same tube complement revealed better than 80% of Brand X receivers survived the 1500-hour test while only 30% of Brand Y sets came through."

"Man, a test program like that certainly turns up some interesting dirt! Tell me more."

"Well, tube failures are classified by type, circuit application, and cause. In the 1960-61 testing period, 72% of tube failures happened in five circuits: u.h.f. oscillator, damper, vertical amplifier, horizontal amplifier, and v.h.f. amplifier—failures occurring in that order. But look at the improvement that has been made: in 1955-56, 34% of the horizontal amplifier tubes failed; in 1960-61, 3%. Vertical amplifier failures fell from 29% to 6%; dampers, from 33% to 9%; and v.h.f. amplifiers from 22% to 2%.

"In 1955, 7.7% of the tubes tested did not survive the test. In 1960-61, only 2.9% failed. Adjusting this figure for normal operation of TV sets at 117 volts, we come up with the astounding anticipated failure rate of one-half of 1% per 1000 hours of operation. Pretty good, huh?"

"Darned good. What caused most of the failures?"

"In 1955, it was shorts, open heaters, gas, open welds, and miscellaneous causes, in that order. In 1961, it was shorts, miscellaneous causes, open welds, arcing, open heaters, and gas, also in order. Notice the improvement made in heater failures and gas elimination. Heater failures fell from 1.86% to .19%; gas failures, from 1.50% to .095%.

"In 1961 u.h.f. oscillator tubes failed at the rate of 13%—the highest rate of any type—but investigation revealed four models by two manufacturers contributed very heavily to this figure. Three of the receivers were portable, and the fourth was very compact. Eliminating data from these four models reduced the failure rate to 5.3%—another example of how receiver design influences tube failure.

"Care must be used in interpreting the data. For example, in 1959-60, the average per-cent of failures per 1000 hours for single-section tubes was 2.3% as opposed to 1.6% for double section tubes, such as dual triodes. It seemed double-section tubes were more reliable than single-section ones until it was realized single-section types included horizontal amplifiers, dampers, and high- and low-voltage rectifiers. With these workhorses excluded from the comparison, the failure rate was identical. Apparently set life is not shortened by using double-section tubes—good news for compactrons!

"How about series-string filaments *versus* transformer sets?"

"This finding astonished me. Testing periods ending in 1955 and 1956 showed series-string sets to have longer life than transformer-powered receivers. Since that time, though, no significant difference in tube life in the two types has been noticed."

"You were surprised the series-stringers lasted longer?"

"That's right, but I was thinking in terms of the little a.c.-d.c. radios that connect strings of filaments directly across the line. As we both know, current surges through these cold filaments are very substantial and not at all conducive to long life. But ballast resistors in the TV sets reduce these surges to values even below those taking place in transformer receivers, and that makes the difference."

"Well, I'm considerably smarter than I was an hour ago." Barney reflected smugly. "I know tubes are much more reliable now than they were ten years ago; I know raising the line voltage thirteen volts makes tube failure four times as likely; I know the design of a receiver has a lot to do with tube life; I know properly designed series-string filament arrangements are not necessarily harder on tubes; and I know putting two tube sections in a single envelope does not shorten the tube life."

"You might consider one more thing," Mac suggested as he stood up and stretched lazily. "Going back to the tube-pricing subject that started all this discussion, learning these things about tubes and putting that knowledge to work to lengthen tube life must also be figured into the cost of tubes—but it's certainly worth it." ▲

HAM MEETS SCHEDULED

THE Montgomery Hamfair will be held at the State Coliseum in Montgomery, Alabama on April 15th. Complete details on the event are available from any Montgomery station or write Montgomery Amateur Radio Club, PO Box 6187, Montgomery 6, Alabama.

* * *

THE Dayton Hamvention, now in its 11th year, will be held on April 28th at the Dayton Biltmore, Dayton, Ohio. The Dayton Amateur Radio Assn., Inc. are hoping to top last year's attendance record of 4000 registrations. ▲

ELECTRONIC CROSSWORDS

By BRUCE BALK

(*Answer on page* 106)

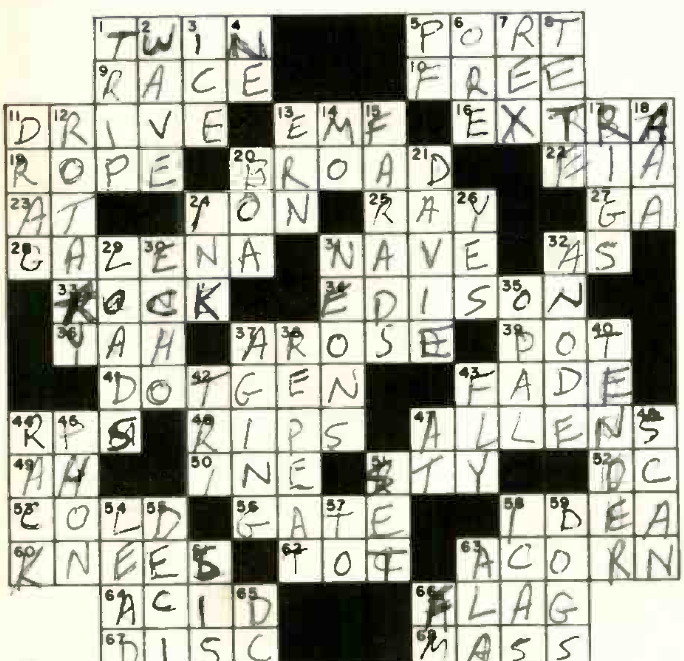
(Answer on page 106)

ACROSS

1. Transmission line having two parallel conductors.
5. Vent used in a bass-reflex enclosure.
9. Run.
10. Floating grid.
11. Belt which transmits power from a motor to the driven device.
13. Abbreviation for electromagnetic force.
16. Ham license classification.
19. Product of hemp.
20. Wide frequency range.
22. Industry trade association.
23. Crystal cut.
24. Charged particle.
25. Gamma or x-____.
27. Southern state (abbr.).
28. Crystal.
31. Part of a church.
32. Like.
33. Rotate a tuning control.
34. Type of storage cell.
36. Affirmative (slang).
37. Got up.
39. Variable resistor.
41. Tester used to adjust convergence controls (familiar).
43. Gradually change in signal amplitude.
44. Rotational speed (abbr.).
46. Tears.
47. Type of setscrew (pl.).
49. Exclamation.
50. Chemical suffix.
51. Pig pen.
52. One type of electric flow (abbr.).
53. Tube having no external source of heat for its cathode.
56. Voltage used in electronic counters.
58. Thought.
60. Top bends of tube characteristic curves.
62. Youngster.
63. Early u.h.f. tube.
64. Quality measured by Ph.
66. CRT part on which getter material is deposited.
67. Phonograph record.
68. Weight divided by acceleration due to gravity.

DOWN

1. Open a circuit.
2. Band of assigned frequencies.
3. State of water.
4. It's used in some pilot lights.
5. Ratio of actual power of an alternating current to the apparent power (abbr.).
6. Unrefined metal.
7. King (Latin).
8. Head (Fr.).
11. Stylus cutting angle.
12. Type of switch.
13. Sea eagle.
14. Midwestern state (abbr.).
15. Units of capacitance.
17. Radio sets (to hams).
18. National motorist's organization (abbr.).
20. Giant snake.
21. Boy's name (diminutive).
24. Writing fluid.
26. Affirmative.
29. Devices that absorb power.
30. A reverberant chamber.
31. Lamps using a rare gas.
32. A tube's electrode.
35. Semiprecious stone.
37. Descriptive of electronic components which have been stored.
38. To say again.
40. Sensitive.
42. Numerical prefix.
43. Circle cutter.
44. Electronic equipment panel.
45. Unit of loudness.
47. Situated.
48. Electronic display of a scene in television.
51. Receiver.
54. Connecting wire.
55. Prefix denoting "ten."
57. Preposition.
58. Abbreviation used in power ratings of components.
59. Tough service jobs (colloq.).
61. Family member.
63. ____ mode.
65. Amplifier in which plate of each tube is connected directly to the grid of the next tube.
66. Type of radio transmission.



"ONE-UP-MANSHIP" FOR THE AMATEUR

By B. C. HOWARD

IT HAS been truly said that he who is not "one up" is automatically "one down." This axiom is as true in the sphere of amateur radio as in any other field: it therefore behooves each amateur to establish a superior position at the earliest opportunity.

It is with this intention that the following ploys are suggested. In establishing contact, be sure that you give the other station's report before you obtain yours. You should report along the lines of "your carrier is strength nine plus, old man, but the modulation is low—all in the middle so to speak, and not much of it." This can be amplified by suggesting rare faults such as "round the world echo" on one sideband or if the quality is perfect, do not hesitate to say so, adding, "for a carbon microphone."

Always try to use unusual phonetics for call signs, etc., and do not scorn the use of strange or non-existent combinations of the "Q" code, calculated to send the other fellow flying across the shack to find his copy of the code. Do not fail to ask how much DX your fellow ham worked the previous night, when you know that conditions were really foul.

If you work c.w., always try to send faster than you know the receiving station can receive; if possible, get hold of a bug key and send extra dots at times. This will wear down the strongest nerves. When you receive the inevitable request to send more slowly, send really slowly—about four words per minute. This should do much to foster the "ham spirit."

Let us assume that you wish to work on a particular frequency which is already in use, the tactics to be adopted here are to break in and accuse the occupiers of usurping "your frequency," claiming that you are in contact with a DX station that they cannot hear. This should be followed up with disparaging remarks on the receivers in use at certain stations. As an alternative, you can break in and tell one of the stations that his signal is really atrocious and that he ought to remedy it fairly soon. In keeping with the "ham spirit," you should always add, "I thought you would like to know this and I only broke in to be of some assistance." Another ploy which is helpful, is to state your intention to go QRT and then proceed to go back for three or four "finals."

Special cases demand special treatment and when taking part in a contest use should be made of calling a rare DX station for some time, to be followed by one side of a fictitious conversation with him.

Finally do not overlook the judicious use of the tape recorder. By means of superimposing, various forms of distortion can be pre-recorded. This should insure that on playback, what the distant station hears is a travesty of his original signal, *quod erat desideratum.* ▲

INVITATION TO AUTHORS

Just as a reminder, the Editors of ELECTRONICS WORLD are always interested in obtaining outstanding manuscripts, for publication in this magazine, of interest to technicians in industry, radio, and television. Articles covering design, servicing, maintenance, and operation are especially welcome. Articles on Citizens Band, audio, hi-fi, and amateur radio are also needed. Such articles in manuscript form may be submitted for immediate decision or projected articles can be outlined in a letter in which case the writer will be advised promptly as to the suitability of the topic. We can also use short "filler" items outlining worthwhile shortcuts that have made your servicing chores easier. This magazine pays for articles on acceptance. Send all manuscripts or your letters of suggestion to the Editor, ELECTRONICS WORLD, One Park Avenue, New York City 16, New York.

Transistor Digital Circuits

(*Continued from page* 31)

transistor and found to be as follows:

	V_1	V_2
Emitter	0 v.	0 v.
Base	0 v.	+1 v.
Collector	0 v.	−10 v.

These are normal with V_1 conducting and V_2 cut off. (V_2 collector voltage may vary with output load.)

To determine if the flip-flop can reverse states, a home-made signal is applied to make the previously conducting stage non-conducting which, in turn, should flip the associated stage to the conducting state. The home-made signal is applied simply by using either a small screwdriver or a soldering tool in the manner already described (Fig. 5), to short the emitter to base of the conducting stage. Momentary shorting should be sufficient to reverse states.

In the example just discussed, the emitter of V_1 in Fig. 8 is shorted to the base and the collector voltages of V_1 and V_2 are then re-checked. Collector voltage of V_1 should now be −10 v. and V_2, 0 v. If the states have not reversed, a further check is made of each stage, following the inverter troubleshooting checks previously mentioned to localize which transistor state is defective.

If both stages are conducting or both non-conducting, checks are made around each stage as for an inverter.

If the flip-flop reverses normally, a further check is made to see if it reverses a second time to the original state when the same momentary shorting check is applied to the other transistor (V_2 in this case). If reversal occurs, this indicates the flip-flop is operating normally and the trouble may be either in the input circuit to the flip-flop or the output circuit from the flip-flop to the following stage. For example, if input diode CR_1 is open, the flip-flop will not be triggered properly (cut off) when an input signal is applied to V_1. Therefore V_1 conducts continuously and V_2 remains cut off.

The counter shown in Fig. 9 is a series of flip-flops functioning as a frequency divider. Pulses at a given frequency are applied to FF_1. Output from FF_1 is a square wave at half the original frequency, output of FF_2 a square wave at one-quarter the original, etc.

Signal tracing with an oscilloscope from stage to stage quickly shows which flip-flop is not functioning. Then further troubleshooting checks can be performed on that flip-flop as described previously, after disabling the normal signal input. For example, if the output of FF_2 is normal and there is no output from FF_3, a further check is made around the latter. On the other hand, if the input to the counter is normal (input to FF_1), but there is no output from FF_1, a further check is made around that flip-flop. In this case, it is important to check that the reset line does not have a steady re-set voltage present, since this would prevent the counter from operating. ▲

Reverberation in Audio

(Continued from page 40)

Another troublesome feature of the acoustic pipe delay line is the fact that the signals from the pickup microphones must be fed back into the driving speaker in order to obtain long synthetic reverberation times. Even a 100-foot pipe will only give a distinct delay of about one-tenth of a second. Feedback will consequently have to be used to continue the delay train through the system. These problems, as well as the generally rather poor over-all frequency response of the acoustic pipe delay line, as shown in Fig. 7, have caused them to be primarily research laboratory curiosities at best.

Tape Delay Lines. Magnetic tape delay lines are being commercially produced by a number of companies. These systems, as shown in Fig. 8 and in the photographs, utilize a recording head, a moving magnetic medium (such as magnetic tape, drum, or an endless belt), and one or more reproducing heads staggered after each other. In a sense, the magnetic tape delay system is the same as the acoustic pipe delay with the recording head taking the place of the transducer, the magnetic tape the place of the pipe, and the playback heads the place of the pickup microphones. Although this system has a wide frequency response, it too requires feedback techniques for lengthy reverberation times. A typical commercial re-entrant tape reverberation system (*i.e.*, using feedback) may have as many as nine tape heads. Seven of these are staggered playback heads giving the initial delays. By means of feedback, a reverberation time of five seconds can be achieved with a frequency response of ± 1 db from 100 to 8000 cps.

In such a system, playback heads may be staggered so far away from the recording head that extreme eerie echo effects will be obtained. These effects, as well as others, are often required by broadcast studios to obtain "haunted-house" or "ghost-voice" effects.

Certainly the tape delay system offers the widest variety of effects and is the most flexible reverberation device in use today. Its frequency response is fairly broad and distortion is quite low. The amplitude decay characteristics of the echoes are exponential and in this respect the device approximates room characteristics.

Mechanical Delay Lines. In the mechanical delay line, a transducer is used to excite a length of rod, a spring, or a metal plate. A pickup is placed at the end of the rod or coil or somewhere in the plate to detect the sound energy transmitted through the metal medium. One of the most important features of this type of reverberation device is the fact that a single transducer and a single pickup system gives an extensive, continuous basic reverberation train, not like the tape system whose basic, discrete reverberation trains are determined by the number of playback heads used. This condition is due to the

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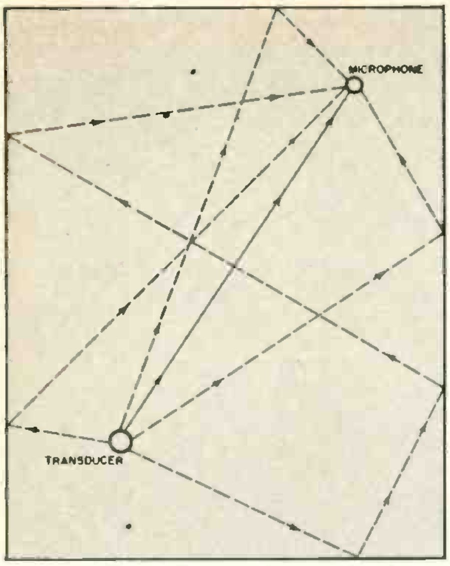


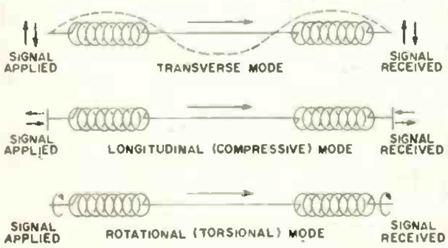
Fig. 9. Plan view of metal plate (approximately 5'x10'x¼") excited in transverse mode. Direct sound and echoes are shown.

fact that the sound waves continue to bounce back and forth in the metal transmission medium, as shown in Fig. 9.

Although spring and plate reverberation systems give continuous echo trains decaying in an exponential fashion, they do have a number of drawbacks. First of all, the velocity of sound through a metal medium is 10 to 15 times faster than the velocity of sound through air. Thus, in order to achieve a suitable delay, the signal must be reflected back and forth many more times than in air. Consequently, a metal plate 8 feet by 3 feet, in terms of decay time, is only equivalent to an air cavity approximately 2 inches by 6 inches. In addition, metal delay lines have internal resonances and these resonances show up in the output. (The damping of springs, for instance, varies with frequency.) As a result of these internal resonances and because the sound has to be reflected many more times than in air to achieve a similar delay, the quality of the reverberated sound in spring and plate delay lines often has a metallic twang, flutter, and a ringing quality.

Mechanical reverberation systems using wire, springs, or rods can be excited by the transducer in the transverse mode, the longitudinal mode, or the rotational mode, as shown in Fig. 10. If excited in the transverse mode, the sound-wave propagation speed is determined by the tension on the spring or wire. This technique results in certain non-linearity in the propagation velocities as a function of frequency. In addition, the transverse system is also

Fig. 10. Transmission modes with spring.



very sensitive to outside shock and vibration. In the longitudinal system (sometimes called the compressive system) the signal velocity is practically constant throughout the audio frequency and spring or wire tension does not play a part in the end result.

With longitudinal transmission there is a fairly high susceptibility to outside vibration and shock. In addition, if a coil spring is used, large dynamic excursions may actually cause coil turns to touch each other, producing considerable distortion.

By far the most popular method of producing synthetic reverberation by means of a spring or wire utilizes the rotational technique. This technique offers wide dynamic range and is less affected by extraneous noise and shock. This type of system has found great popularity in a number of commercially produced synthetic reverberation devices, most built around the patented *Hammond Organ* spring mechanical reverberator. This unit utilizes two springs about 14" long in coiled form, as shown in Fig. 11. The two springs

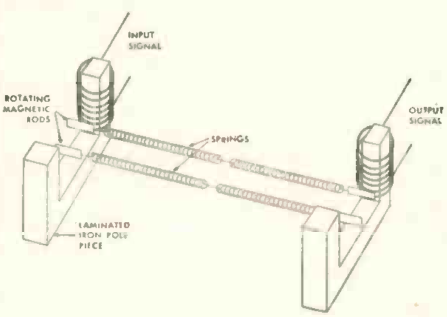


Fig. 11. Spring reverb system developed by Hammond Organ Co. (Courtesy: Motorola.)

are driven in the rotational mode by a transducer at one end. A unique reverse twist in the center of each spring reduces unwanted extraneous vibration. One spring gives a delay of 29 milliseconds (after internal reflections) while the other spring gives a delay of 37 milliseconds (after internal reflections). Both of these delays are picked up by a single pickup exactly like the transducer at the other end.

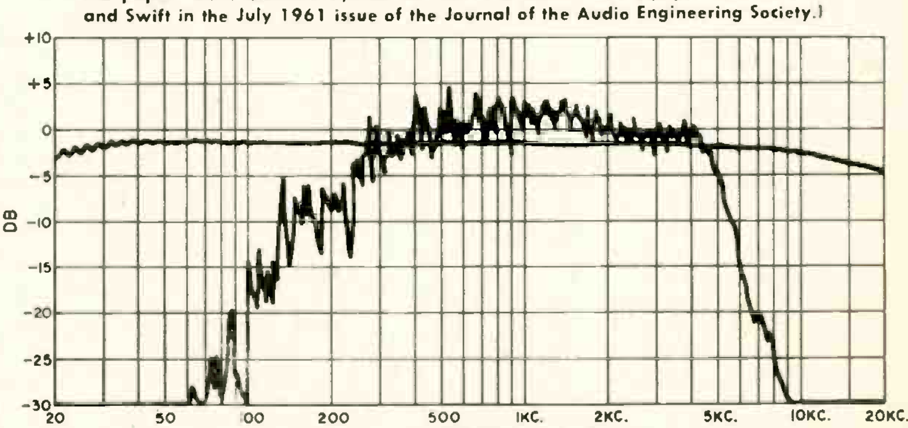
As we have seen before, the *Hammond* reverberation springs can be considered as improperly terminated transmission lines for acoustic energy. As a result, the signal continues to bounce back and forth in the spring, resulting in a maximum reverberation time, with feedback, of 2 seconds. The reverberation time control in one version of the *Hammond* unit consists of a potentiometer acting as a variable gain control in the echo amplifier section of the circuit. The frequency response of this unit is shown in Fig. 12.

In addition to the *Hammond* unit, variants of which are now selling for $50 to $90 including all the electronics involved, another unit, much larger and primarily intended for broadcast use, should be mentioned. This unit is a reverberation plate produced by the European firm *EMT*. This unit consists of a specially produced steel plate measuring about 3 feet by 9 feet. The plate is laterally excited by a dynamic driver and the signal is picked up by a contact microphone. The sounds bounce back and forth in a nearly infinite train and the reverberation time of the plate can be adjusted from one to five seconds by means of an acoustically absorbent pad which is mounted parallel to the sound plate, moving near it for minimum reverberation and away from it for maximum reverberation.

Summary

In summation, a number of synthetic reverberation devices are currently available. A reverberation device which most closely approximates the conditions encountered in a room must provide a large number of echoes (sound reflections) occurring after the initial sound. These echoes should decay smoothly and exponentially with succeeding echoes coming at shorter and shorter intervals. System resonances and non-linearity in damping must be avoided. In addition, undesirable "tunnel" or "cave" effects will result if the echo train in the system repeats with periodicity because of standing-wave problems. Regrettably, these conditions are likely to be encountered in the essentially one-dimensional sound propagation modes associated with most synthetic reverberation devices. ▲

Fig. 12. Frequency response of reverb channel in Philco console taken straight through the amplifier (top curve) and through the delay line and amplifier (bottom curve). The delay line used is the Hammond two-spring unit. (Curve from the paper "Reverberation System for Home Entertainment Equipment" by Dow and Swift in the July 1961 issue of the Journal of the Audio Engineering Society.)



Dynamic Scope Tests

(*Continued from page* 48)

plate connector is removed from the top cap of the horizontal-output tube, removing the latter from its connection to the transformer. The vertical-input lead from the scope is connected to the removed connector for the plate cap, which goes to the transformer. The ground lead from the scope goes to chassis ground or "B−" on the TV set, whichever is used. After the scope is adjusted (assuming a TV receiver in good working order), a display like that in Fig. 1 is obtained.

Now replace the high-voltage rectifier in its socket: many technicians will want to start their checks of the flyback system in this way. Since the resonant frequency of the system has been changed, the scope's frequency control will probably have to be re-adjusted to obtain the display of Fig. 2. The jagged appearance and increased damping of the wave is due to the loading of the transformer by the rectifier filament. Aside from this, the indication is normal.

Now short out the filament winding of the high-voltage rectifier. This can be done conveniently at the rectifier socket. More severely damped, the display will look like that of Fig. 3. This is the indication that will be noted when there is no more than a single, shorted turn *anywhere* in the horizontal sweep system.

By changing the scope's frequency setting, the display of Fig. 3 can be made to appear as though it has a longer duration, as in Fig. 4. However, this is not likely to be misleading. The severely distorted appearance is obviously a departure from a normally damped oscillation. It is a sure indication of trouble in the flyback transformer itself, in the yoke, in a width or linearity coil, in some capacitor connected across any part of the flyback transformer (including any across the yoke winding), or some other component associated with the system that is causing other than normal loading.

Where an abnormal display is obtained, the trouble may be localized further by removing connections from the flyback transformer one at a time. Where the removal of a particular connection restores the normal waveform, we know that the trouble is in that portion of the circuit associated with the particular connection. In this way, troubles may be pin-pointed to specific components.

Other special indications yield strong clues. When the a.c. path is open between the output tube's cap connector and "B−," 60-cycle a.c. will be picked up and displayed as in Fig. 5. This would indicate an open in the transformer winding. A fairly complete short in the circuit—such as a short in a capacitor that is shunted directly across part of the transformer—would produce no deflection (no oscillation) at all. The display would be a straight line.

If you wish to check a replacement

flyback transformer before installing it, connect the scope input leads between the plate-lead connections for the horizontal-output and the high-voltage rectifier tubes. To check a replacement yoke, first connect the scope across the horizontal coils. Then perform the test across the vertical coils, but be sure to remove any shunting resistors temporarily or oscillation will not be sustained. In all of these checks, a "clean" display like that shown in Fig. 1 is a "good" indication.

A vertical-output transformer is tested with the scope connected across the primary. In an autotransformer, scope leads go to points *1* and *2* in Fig. 12. The yoke windings must be disconnected; this is done by breaking the connection at point *3*. If the transformer is good, the display will be like that of Fig. 6. The reduced number of cycles in the normally damped wave (compared to Fig. 1) are to be expected in a low-*"Q"* iron-core device of this type. Nevertheless, the waveform obtained with a defective transformer will be distinctly different.

An audio-output transformer, like a vertical-output transformer, is a low-*"Q"* iron-core device. A shorted turn or so in its primary can also be located with the CRO test. Under normal conditions, its waveform under test will also be that of Fig. 6. To obtain this display, the scope is connected across the primary—points 3 and 4 of the single-ended transformer in Fig. 13. The plate bypass capacitor (C_1) must be disconnected for the test. If the secondary is shorted, primary inductance is substantially reduced. The display will then resemble that of Fig. 1. A short in the primary, on the other hand, will reduce the damped waveform or kill it altogether. This check at the output transformer has been useful in solving obscure causes of distortion.

Video peaking coils (Fig. 13) can also be checked. Those not shunted by resistors (L_2, L_3, and L_4) are checked by connecting the scope leads directly across each coil. To check L_1, which is usually wound on the body of a resistor of low ohmic value, disconnect one lead of the coil from the resistor body to check across the coil alone.

Such 4.5-mc. coils or tanks as sound take-off L_5 and quadrature coil L_6 in Fig. 13 may be checked respectively from point *1* to ground and point *2* to ground. The ringing coil of a horizontal oscillator (Fig. 14) may also be tested. A scope connection between point *A* and "B−" or chassis ground will prove out coil L_7 and its shunt capacitor. Although many inductive components and circuits in a TV set may be tested in this way, the check is not recommended for video i.f. transformers. The *"Q"* of these components is usually too low to permit a usable damped wave of oscillation to be set up.

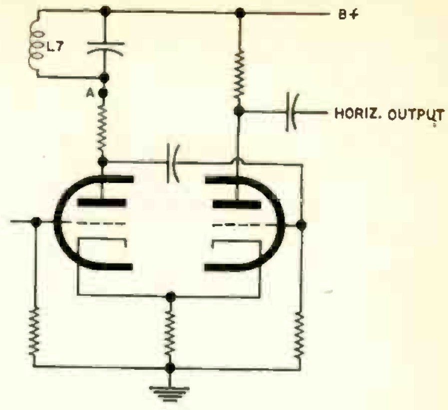


Fig. 14. Horizontal-oscillator ringing coil is checked from point A to ground.

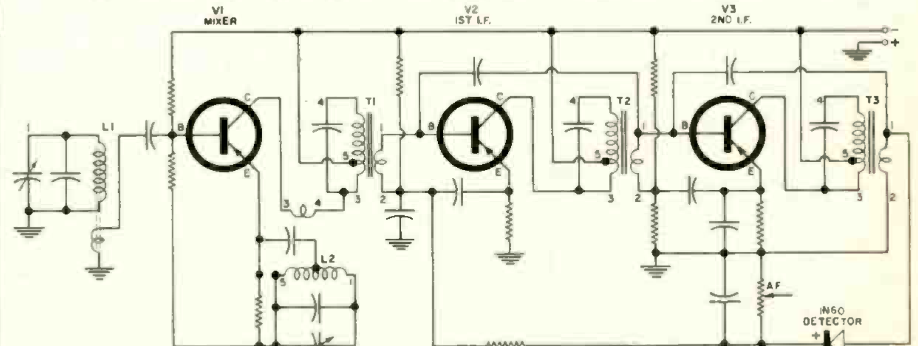
Testing Radios

To check resonant circuits in a radio receiver, turn off the set, connect the scope's ground lead to the radio chassis or other ground, then connect the combined lead from the scope's vertical input and blanking pulse to the hot side of the circuit or component being checked. For a ferrite-core antenna, for example, this would be the stator of the r.f. tuning capacitor. A useful test can be made here by tuning the radio through its range while observing the waveform display. If the waveform suddenly collapses to a straight line at any point, the tuning capacitor's plates are shorting at that point. The same test can be used on tube and transistor receivers.

To check i.f. transformers in a tube receiver, connect the scope between the transformer's plate connection and "B−" for a test of the primary. The secondary may be checked by shifting the hot lead from the scope to the following grid.

The front end and i.f. amplifier of a typical transistor radio is shown in Fig. 15. For proving out these circuits, the ground lead of the scope is connec-

Fig. 15. Antenna, oscillator, and i.f. coils can be checked in transistor radios.



ted to a convenient ground point in the receiver. This may be to the chassis or, if a printed board is used, to the frame of the tuning capacitor. Consider the first i.f. transformer, T_1. The vertical and pulse lead of the scope connects to point *3* on the transformer can. A damped wave of small amplitude will be noted if the circuit is not defective. A much larger display will result if you connect to point *4*, the unused primary lug, instead of point *3*. The other i.f. transformer primaries can be checked in the same way, at the same numbered points.

The secondaries are best checked with an ohmmeter (between points *1* and *2*), but make sure that the d.c. test voltage of the latter is no more than 3 volts. Under these conditions, neither the ohmmeter nor the test pulse will damage the transistors. It is not necessary to remove any of the latter from the circuit. The oscillator tank is checked between point *1* and point *5* or ground of L_2. The ferrite-core antenna is checked at point *1* of L_1.

With these tests and the check of the audio-output transformer noted earlier, extensive stage-by-stage checks in a radio are possible. These can assist greatly in trouble localization. In the case of the TV receiver, although resonance tests are not recommended for all circuits, many portions of the design that are otherwise difficult to check may be examined critically. All in all, the method described here represents a useful and broadly applicable bench technique in servicing. ▲

EIA ENGINEERING GROUP TO MAKE AM STEREO STUDY

THE Engineering Department of the EIA has announced its intention of making a study of proposals for stereo radio broadcasting in the AM band.

The purpose of the study, according to James D. Secrest, EIA executive vice-president, is to lay the basis for determining whether preparation of a formal proposal to the FCC on AM stereo would be warranted.

More than 50 FM stations have gone on the air with stereo broadcasts since the FCC authorized the service last year. The authorization was based on technical studies, made at the FCC's request, by the EIA-financed National Stereophonic Radio Committee.

Heading this new group is C. J. Votava of the Delco Radio Division of General Motors Corp. According to Mr. Votava, the immediate goal of the group will be to determine the necessity of a more complete, thorough survey of the AM stereo situation. If the initial study indicates need and interest in the possibilities of AM stereo, a program similar to that undertaken for analysis of FM stereo would be recommended to EIA.

Manufacturers, broadcasters, and other companies with an interest in AM stereo have been invited to submit the names of their representatives to Mr. Votava in care of the EIA Engineering Dept., 11 West 42nd St., N.Y. 36, N.Y.

Companies having technical proposals covering AM stereo systems are asked to submit brief statements describing such systems. These would be used as background information in the initial phases of the study. ▲

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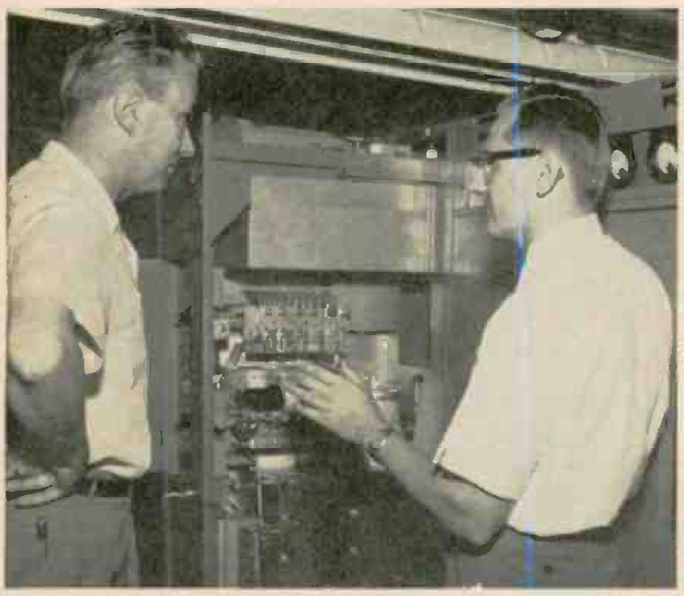

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#25

A SOLDER REMOVER

By **JOSEPH J. RUSSO**

ANYONE who has had to remove a component from a printed-circuit board and put in a new component in its place, or has had to remove a component from a tube-socket pin and then install a new component, has run into the problem of removing the solder from the terminal or pin.

A very unique device for removing the solder before and after removing the component from the terminal, is presented here.

There are only three parts to the "solder remover"—an ear syringe, a length of #14 Teflon tubing (about 4" long), and a length of #16 bus wire (about 6" long).

The tubing is inserted into the end of the syringe. The wire is used to remove the solder that has collected in the tubing.

The operation of the "solder remover" is as follows:

1. Heat the terminal that is to be worked on.

2. With the other hand, pick up the solder remover and squeeze the syringe.

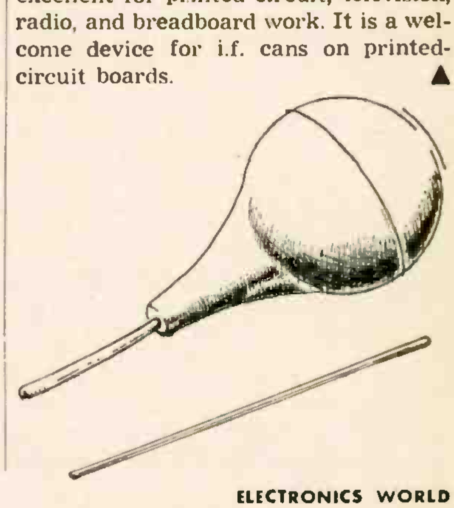
3. When the solder is in its liquid state, touch the end of the tubing to the terminal and release the pressure on the syringe. This will create a suction that will remove the solder from the terminal.

Removal of the component on the terminal can now be accomplished quite easily.

After the component has been removed, the remaining solder on the terminal can be removed by the same method.

After 2 or 3 operations, remove the Teflon tubing from the syringe and insert the bus wire into the tubing to remove the solder that has collected on the inner walls of the Teflon tubing.

This technique for removing solder is excellent for printed circuit, television, radio, and breadboard work. It is a welcome device for i.f. cans on printed-circuit boards. ▲



PHONO SALES in 1961 OFF FROM PREVIOUS YEAR

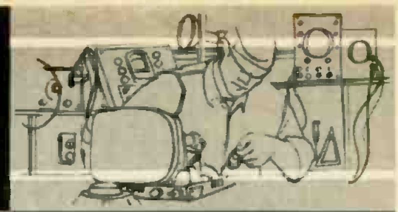
THE Marketing Data Department of the Electronic Industries Association has reported a drop in phono sales for the period through November 30, 1961 as compared to a similar time space in 1960.

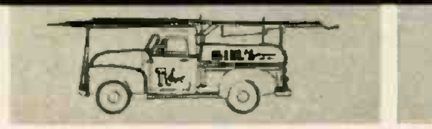
Factory sales of stereo phonographs, however, reached a total of 358,285 in November, a monthly high of 1961. November sales of mono sets declined to 141,083, ending a steady monthly rise which began in May. October was the previous high month for sales of both types of sets. Stereo sales totaled 350,254; monophonic equipment sales stood at 151,580.

Cumulative totals through November showed sales of both stereo and mono sets behind those for the same period in 1960. Totals were 2,586,163 stereo units sold in 1961 as against 3,044,702 sold in 1960 and 955,609 mono units sold in 1961 compared with 1,059,617 in 1960. Monthly sales figures, January through November, for both 1960 and 1961 are shown in the table below. ▲

	Monophonic	Stereophonic
November	141,083	358,285
October	151,580	350,254
September	124,142	328,045
August	106,157	242,164
July	70,681	171,331
June	61,533	197,170
May	53,887	142,450
April	53,074	152,974
March	62,396	227,469
February	50,710	204,638
January	80,366	211,383
Year to date 11/30/61	955,609	2,586,163
Year to date 11/30/60	1,059,617	3,044,702

SERVICE INDUSTRY NEWS





IS ONE OF THE grand illusions of the domestic service industry about to fall by the wayside? Is an idol being toppled? For many years, the TV service technician in this country has eyed his British counterpart with awe and envy. The idealized status of the latter was a goal that could be striven for only in the hope of partial success. He was a man who had everything. Or so the thinking went.

His very title was indicative. Certainly no one would think of calling him a slob or a thief. Nor was he regarded as a mere mechanic or repairman. In fact, even so respectable a designation as technician was not good enough for him. The idol was known to his following as a Television Service Engineer.

And this title, though perhaps not so high up in the peerage as prince or even duke, bespoke status. Thus he was looked upon by those he would deign to accept as customers as an Important Man of Science. His pronouncements concerning the conditions of errant receivers were never questioned. Nor were his fees. He was a professional man. He made a good living, although he never had to overwork. Best of all, he was regarded with deep respect by his neighbors. On the other side of the coin, he had earned such honors because he was a highly competent sort. How green the grass!

The idyllic picture has been shattered by a dispatch from London: the Consumer Advisory Council of the British Standards Institution has done some snooping into the matter of TV repair. The mere fact that the council saw fit to question the purity of the hallowed industry threatens the cherished myth. Its findings are still more jarring.

Rigged Set Used

The council bought a TV set, British-made of course, that was considered rather simple to service. A couple of rather simple defects were inserted in the otherwise properly operating receiver and then the fun began: the first shop was called for service. The shop took 11 days to complete the repair (ah, the leisurely English) and charged the equivalent of $12.81. Workmanship was good and service was courteous.

The two defects were re-inserted in the repaired receiver and a second shop was called in. The set was returned two days later with a charge of $5.15. The picture was still somewhat faulty, but it was judged that the repair would have satisfied most people. The man from shop number 3 took two days to make the set worse than it was before he got it. However, no bill was submitted. A letter of inquiry went unanswered. The fourth shop charged $8.82 after four days. Neither fault was correctly repaired. A tube that did not need replacing was replaced. The fifth shop took four days and charged $5.45. A new tube was replaced by one more than three years old. The sixth shop charged $7 after two days. Only one of the two inserted faults was repaired.

Even the English, we can see, do not believe that their vaunted Service Engineers are faultless. As for our own technicians, they can now stop daydreaming. Once more, they can devote full vigor to such real issues as drugstore tube sales, retailing wholesalers, captive service, licensing, consumer confidence, the $2 service call, and other authentic problems of earning a living.

Another License Law Passed

Licensing has become a "hot" issue again of late, with something to show for all the talk, this time around. For the second month in a row—a situation without precedent—we can report the actual adoption of enabling legislation. On the heels of service licensing in South Bend, Ind. (see this space last month, page 90), the city of Buffalo, N. Y. has come up with its own ordinance. The Buffalo City Council enacted the law unanimously.

Annual fee for a master technician is $50, with that for an apprentice being $25. For the rest, the law is closely patterned after the Cooke-McClosky Bill introduced in the state legislature last year and defeated—but not by a great margin, in one house, after having passed the other. Re-introduced this year, the state-wide bill is believed to have a very good chance of becoming law.

New Manufacturer Warranty

Every new variation of the service warranty by the set manufacturer sets off another round of jitters, not always justified, through the independent service industry. The big problem is to figure out what each new wrinkle is going to mean in the future. *Westinghouse* is bound to cause much head scratching and educated guessing with its own twist on the printed-board guarantee.

"All deep-etched circuit boards used in 1962 *Westinghouse* TV sets," says K. H. Brown, the TV-radio division's national service manager, "are guaranteed against basic failure of the board material and the bonded circuitry." At first volley, this sounds like one of those diabolical warranties that does not include the *components mounted on the board*. The next statement, however, brings forth a sigh of relief: "Should the company determine that such a failure has occurred within the first year's use, *the complete receiver will be replaced* without cost to the original purchaser. The replacement will be an identical model if available or one of the closest similar description and value as decided by the company."

So far, the conditions sound clean and uncomplicated. However, a final statement concerning conditions that void the warranty include "any instrument that has been serviced by unauthorized service personnel." Without a clear-cut definition of what constitutes authorized and unauthorized personnel, we may have a new round of head-scratching under way.

Dud Law a Dud?

"Despite a state law safeguarding them from the misrepresentation of TV replacement tubes, the majority of New York residents seemingly are not getting the protection they were meant to have," reads a news item recently received. This plaintive release quotes Douglas W. Cook, president of the Empire State Federation of Electronic Technicians' Associations, on a relevant survey recently taken among TV service technicians in the state. The technicians say, according to Cook, "that few or none of their customers knew the law existed . . . effectiveness of the law is up to the customer as well as the technician."

Other information turned up by the survey: half of the technicians queried state that most of the replacement picture tubes they sell are rebuilt. Only one customer out of ten had any complaint to make about getting a rebuilt tube.

There is little doubt that, if the rebuilt replacements were labeled in strict accordance with the law, more customers would complain, simply because the required wording seems like something to complain about to the non-technical mind. As things now stand, the only cause the customer has for complaint is the performance of the replacement tube, if it is below standard. As long as a good rebuilt that will give him acceptable performance is used, there is no cause for complaint. Unfortunately, the labeling law is not concerned with the *quality* of the picture tube, whether new or rebuilt. The item in question was released by the *Kimble Glass Co.*

Of greater interest to many, particularly those concerned with the pros and cons of licensing, is the reaction of service technicians to the latter subject. More than 75 per-cent of the technicians who responded to the survey felt that a licensing law would help overcome the problems faced by the service industry today. The sampling certainly does not reflect industry feeling on this matter on a nation-wide basis. However, it should represent feeling in New York quite accurately. ▲

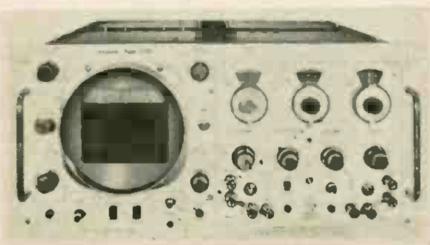
New Products and Literature for Electronics Technicians

Additional information on the items covered in this section is available from the manufacturers. Each item is identified by a code number. To obtain further details, simply fill in the coupon appearing on page 108.

DUAL-TRACE STORAGE SCOPE

1 Analab Instrument Corporation has announced the availability of a new dual-trace storage scope and X-Y recorder that features an "electronic scratch pad" for previewing data prior to freezing it on a separate storage area.

The Type 1220 is said to be the first such instrument to incorporate a raster-scan system



to store data on a one-, five-, or ten-line display. The raster scan can be manually or automatically indexed and operated for single- or dual-channel presentations. At the slowest available speed, data may be recorded over a 20-minute period and will remain stored for over a year, even with the instrument's power off. The storage target may be erased in 30 seconds.

MINIATURE INDUCTORS

2 United Transformer Corp. is in production on the "Miniductor" series of miniature inductors which has been especially designed for transistor and printed circuit applications. All units conform to MIL-T-27A specs.

The new line is offered in inductances up to 5 hys. and are adjusted to a tolerance of ± 1%. Temperature stability is provided from −55 to 100 degrees C. The coils are symmetrically wound toroids for high coupling attenuation and low hum pickup. The units are hermetically sealed in a molded case which measures 23/32" in diameter and 13/32" high. Weight is .25 ounce.

GRID-DIP METER

3 James Millen Manufacturing Company, Inc. is now offering the Model 90651 grid-dip meter in a convenient polypropylene carrying case which keeps the coils with the unit and protects both.

The unit is a calibrated stable oscillator cov-

ering 1.7 to 300 mc. with seven coils. It has a meter to read grid current. The coil is plugged into the unit so that it may be used as a probe. The instrument is complete with transformer-type a.c. power supply.

Incorporation of the power supply, oscillator, probe, and dial into a single hand-held unit provides a convenient device for checking all types of circuits. The calibrated dial is a large 205-degree drum type which provides seven direct-reading scales of equal length.

IN-CIRCUIT CAPACITOR TESTER

4 Eico Electronic Instrument Co., Inc. is now marketing an advanced Model 955 capacitor tester which permits checking capacitors in or out of circuit, including very sensitive checks for shorts or opens. The test includes a Wien bridge with a unique balancing circuit to allow in-circuit capacitor measurements even when shunt resistances are comparatively low.

The Model 955 will handle capacities from .1 μf. to 50 μf. at ±10% accuracy at any point on the dial, in or out of the circuit. Capacity is read from a 4" Lucite dial after it has been adjusted to null in conjunction with the RC balance control.

The unit will operate on a.c. line voltages from 105 to 130, 60 cps. It measures 8½"x 5¾"x 6" and is offered in both kit and factory wired versions.

TEMPERATURE-DIFFERENTIAL UNIT

5 Winsco Instruments & Controls Company has developed a sensitive instrument for the measurement of small temperature differentials over a wide operating span.

The Model 6040 temperature-differential indicator combines high stability of platinum re-

sistance temperature transducers with maximum reliability provided by completely solid-state circuitry. Input is from two matched platinum resistance temperature transducers. The output is indicated on a self-contained meter, or through a connector, can be displayed on a recorder or galvanometer. The instrument is completely self-contained and includes a power supply and plug-in bridge circuitry.

MOLDED CHOKE COILS

6 Delevan Electronics Corporation is now offering a microminiature series of molded choke coils as standard stock items.

The Series 1025 features a physical size of .10 of an inch in diameter and .25 of an inch long with 35 values, ranging from .15 μhy. to 100 μhy. Core materials used are phenolic in the ranges from .15 to 1.0 μhy., powdered iron from 1.20 μhy. through 27.0 μhy., and ferrite from 38.0 μhy. through 100 μhy.

DATA HANDLING CONVERSION

7 Airborne Instruments Laboratory is now offering a low- and moderate-speed data handling conversion systems pre-engineered to the requirements of medicine, science, and industry.

The systems convert continuous analogue voltages into digital formats compatible with the majority of general-purpose digital computers. The systems can convert to digital form as many as eight channels of analogue data. Input impedance of the systems exceeds 100,000 ohms and input voltage is from −1 to 1 volt. The circuitry is composed of solid-state modules. The analogue-to-digital converter is a successive approximation type and is accurate to 1 part in 500.

UNIJUNCTION TRANSISTOR TESTER

8 Wheaton Engineering Division has introduced a unijunction transistor tester that is simple to operate, compact, inherently reliable, and capable of testing most parameters of uni-

junction characteristics. The instrument was especially designed for electronics laboratories, product inspection groups, etc.

The instrument has a six-position function switch which selects tests for transistor oscillation, intrinsic stand-off ratio, interbase resistance, emitter saturation voltage, emitter voltage, and emitter leakage current. The unit measures 10" x 8½" x 8" and weighs 3 pounds.

TRANSISTOR HEAT SINK

9 Daedalus Company is currently marketing a novel transistor heat sink designed to handle the TO-18 case. In still air the "Clipsink" achieves an approximate thermal resistance of 50 degrees C per watt, while in moderately moving air the thermal resistance drops to less than 15 degrees C per watt. The sink requires a printed-circuit board space of ½" x ½" with a total height of less than ½".

SOLID-STATE POWER SUPPLY

10 George Harmon Co., Inc. has announced the availability of a new lightweight regulated power supply especially designed for technicians working with transistorized circuitry, hybrid tubes, etc.

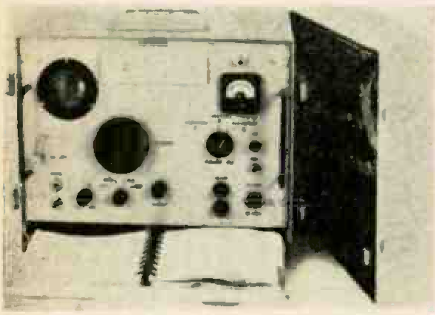
Designated the P-330A, the unit furnishes 0-15 volts d.c. at up to 3 amps. Designed for continuous duty, output is regulated to remain within .1% of indicated voltage with input varying from

105 to 125 volts. Filter circuitry is full-wave series-shunt regulated with four power transistors. Ripple factor is 10 mv. r.m.s. at 50% load and 30 mv. r.m.s. at full load.

PORTABLE FREQUENCY METER

11 Lavoie Laboratories, Inc. has developed a new portable frequency meter featuring a 25% reduction in size and weight, transistorized operation, and a new film calibrated readout.

The Model LA-32 is self-contained and will measure frequencies in the range of 125 kc. to



1000 mc. to a specified accuracy of .01% from −4 degrees F to 125 degrees F. It can also be used as a signal generator for testing and calibrating radio equipment.

The new instrument measures 11½" deep, approximately 13" wide, and 11¼" high. It can be powered by a standard flashlight battery or from an a.c. source of 100-250 volts, 50-400 cps.

TRANSDUCER CONVERTERS

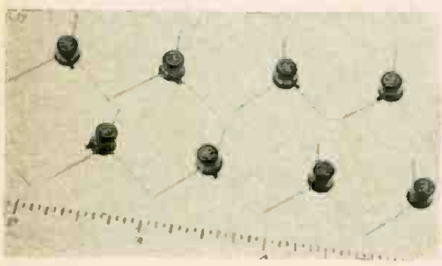
12 Sanborn Company is now in production on a new series of transducer converters which permits the use of differential transformer-type transducers with 28 volt d.c. and 117 volt a.c. power sources. These new converters produce d.c. signals proportional to the input, ready for monitoring or recording with a general-purpose d.c. amplifier. No carrier amplification is needed.

Three models are being offered in the present line with complete specifications available on request.

SWITCHING TRANSISTORS

13 General Electric Company has added ten new high-performance silicon transistors to its line of semiconductor components.

The six switching transistors in this new series have been designed for use in high-speed logic



circuits such as flip-flops, counters, multivibrators, and memory or line drivers, while the other four are designed for use in high-frequency amplifier and oscillator circuits. All ten transistors are housed in the TO-18 standard package.

The featured unit in this new series, the Type 2N914, has a total switching time of 80 nanoseconds. All the transistors are passivated silicon planar types and, in addition, the six switches have the feature of low saturation resistance resulting from the use of an epitaxial layer.

MOLDED CARBON POTS

14 Centralab has just come out with a complete line of 2-watt, hot molded carbon composition potentiometers which are only 1-3/32" in diameter and ⅝" deep.

These new units, designated Model A, are built to meet all environmental and test requirements of MIL-R-94. Features include wide clearance between the bushing and the collector track to provide increased high-voltage stability and freedom from internal shorting; completely enclosed, elevated track construction to reduce the possibility of contamination by dirt, carbon particles, and sealing compounds; and both pick-off and collector brushes of a carbon composition material for noise-free operation.

Detailed specifications are included in Bulletin EP-1234 which is available on request.

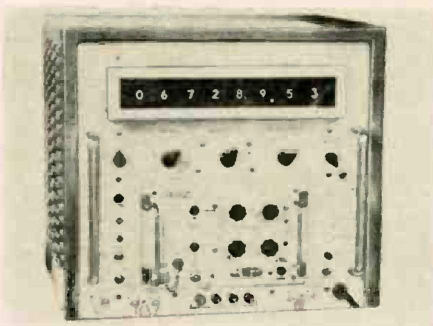
BELLOWS CONTACTS

15 Servometer Corporation has introduced a line of bellows contacts that serve as noninductive springs for electronic assemblies, provide repeatability for any number of re-assemblies, and have low microwave resistance and d.c. electrical resistance.

Made of nickel metal, the contacts have a 24-carat gold surface plated .00004" thick. Five standard contacts provide a range of dimensions, spring stroke, force at full stroke, and metallic ohms resistance. A custom line is also available. As a spring, compression of the contact is equal to 50% of the length of the bellows convolutions. This stroke allows generous follow-up to take care of assembly tolerances.

10 MC. COUNTER/STANDARD

16 Northeastern Engineering, Inc. is now offering a 10-mc. frequency counter/standard which has a basic counter range of 10 cps to 10.1 mc. with an inherent stability of 1 part in 10[8] per day; 5 parts in 10[8] per week. Period and time measurements may be made by counting internal



standard frequency from 0.1 cps to 10 mc. in decade steps and frequency measurements may be made over counting intervals from 1 msec. to 100 sec. in decade steps. Internal self-checking features permit checking the counter circuitry with any of the nine internal standard frequencies in combination with any of six gate lengths.

NUCLEAR COUNTING INSTRUMENT

17 Digital Dynamics, Inc. is now marketing what is said to be the first completely new scaler and events-per-unit-time counting instrument in the nuclear field. The analogue recording dynamic analyzer is either a single- or dual-channel instrument which features high density compactness with fully transistorized circuits.

The standard unit, without plug-in modules, includes a single-channel manual or scanning differential pulse height analyzer, an all-electronic preset count or time register, and an automatic ranging time or count accumulator with analogue output. Plug-in modules and other accessories are available to widen the coverage of this instrument.

MULTI-RANGE D.C. VOLTMETER

18 Houston Instrument Corporation has added the Model HV-160 d.c. servo voltmeter to its line of test equipment for laboratory applications.

The new unit provides very high impedance on all scales. The input is potentiometric (over 100 megohms) on ranges from 3 mv. to 1 volt and is 10 megohms on ranges from 3 to 300 volts. Servo gain is automatically adjusted for each scale by the range switch. Accuracy is .15% on eleven selectable scales.

A double regulated zener reference eliminates reference cell replacement and standardization problems. Indication is provided by knife-edge pointer on a 14" mirror scale. Hardware is provided for rapid conversion from case to rack mounting.

COMPONENT SUBSTITUTOR

19 **Sencore, Inc.** is now offering a compact unit which permits on-the-spot substitution of carbon and power resistors, capacitors, electro-

lytics, and rectifiers. The RC121 is a composite of several of the firm's substitution units which have been housed in a single enclosure with stainless steel handle for easy portability.

CABLE TIE

20 **Electrovert Inc.** has recently introduced a time-saving, lightweight nylon cable tie which features rapid, self-locking action. Taking only seconds to apply, the "Insulok" tie features a non-return, cam-action locking device which insures permanent tying with no slackening. Eliminating the use of tape, string, or similar improvisations, these new ties consist of a single component part, molded from tough, flexible nylon capable of withstanding a temperature range of −80 degrees to +150 degrees C.

The cable tie is currently available in three sizes. A data sheet giving complete specifications is available on request.

HI-FI—AUDIO PRODUCTS

STEREO PREAMPLIFIER

21 **Electronic Instrument Co., Inc.** has added a stereo preamplifier to its "Eico" line as the ST84. Frequency response is 5-25,000 cps ± .3 db; harmonic distortion is .06% at 2 volt output from 20-20,000 cps; IM distortion (60 and 7000 cps at 4:1) is .04% at 2 volts output; hum and noise is −65 db for low-level inputs of 10 mv., −75 db for high-level inputs of 1/2 volt.

Equalization is RIAA for phono and NAB for tape. Tone controls provide 15 db cut and boost at 50 and at 10,000 cps. The circuit uses five 12AX7/ECC83 tubes plus a 6X4. The unit measures 5½" x 15⅞" x 8¾". It is available factory wired or in kit form.

MULTIPLEX ADAPTER

22 **Bogen-Presto Division** is now offering a new multiplex adapter, the Model PX 60, designed to match performance specifications of its own and other high-fidelity FM tuners and receivers.

This self-powered adapter employs four tubes and a germanium diode, providing eight tube functions. Full-frequency performance is assured, even in fringe areas, with ± 3 db deviation from 50 to 15,000 cps.

Front-panel controls include an "in-out" switch and stereo separation control. The adapter measures 4½" x 4½" x 9" and weighs 7½ pounds.

NEW AMPLIFIERS & TUNERS

23 **Grommes** has recently introduced four new and improved amplifiers and tuners, ranging from the low-cost 12-watt LJ8 to the PG Series stereo/mono units and 101GTM stereo tuner which is offered either with or without the multiplex feature.

Complete specifications on these new models are given in a four-page, two-color brochure which also describes other units in the current audio line.

TUNER-AMPLIFIER

24 **Olson Electronics** is currently introducing an AM-FM tuner with 30-watt stereo amplifier that features a snap-in multiplex adapter as an optional accessory.

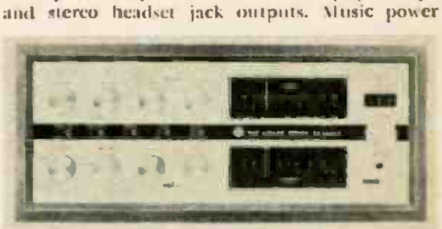
The RA-491 has all the controls including multiplex, balance, ganged loudness control, separate bass and treble controls, noise filter, and mode

controls. Frequency response is 20-20,000 cps ± 1 db; sensitivity is 4 mv. for 20 db quieting; total harmonic distortion is less than 1%. Channel separation is 30 db. The adapter, available at extra cost, is designated RA-400.

STEREO RECEIVER

25 **Harman-Kardon, Inc.** has released its "Stereo Festival III" receiver which provides a complete stereo entertainment center with the addition of speaker systems.

The unit provides three stereo inputs—magnetic phono, tape head, and auxiliary; plus tape and stereo headset jack outputs. Music power



output is 25 watts per channel, 50 watts mono with r.m.s. power output 20 watts per channel, 40 watts mono. Frequency response is 12-70,000 cps ± 1 db at 1 watts. Speaker impedances are 4, 8, and 16 ohms.

The unit provides complete FM and AM sections plus a FM stereo adapter. Frequency response of the adapter is 15-50,000 cps ± 1 db.

FM STEREO ADAPTER

26 **Allied Radio Corp.** has added a low-cost FM stereo adapter to its "Knight-Kit" line as the KS-10. The new unit is designed to be used with any FM or AM-FM tuner equipped with a multiplex jack.

Measuring 2¼" x 9½" x 3½", the adapter is self-powered. The unit's a.c. power cord is plugged into the switched a.c. outlet on the amplifier or tuner, turning the adapter on and off with the component. The adapter also has its own "on-off" switch, noise filter, and separation controls.

CB-HAM-COMMUNICATIONS

TRANSISTORIZED RDF

27 **Raytheon Company** is now in production on a transistorized radio direction finder which will operate from six standard flashlight cells. The Model 356 "Ranger II" is designed to receive

the long-range Consolan direction-finding signals. It has a built-in b.f.o. and covers the Consolan band to receive lines of position from Nantucket, San Francisco, Miami, and the five Consol stations in Europe. In addition, the "Ranger II" covers the regular beacon, marine, and broadcast bands.

The case is made of aluminum with an epoxy finish. Azimuth scale and rotating antenna are of Tenite. All electronic components have been specially treated to resist dampness and corrosion.

NEW CB TRANSMITTER

28 Browning Laboratories, Inc. is now offering a new CB transmitter which features a unique all-channel selector which enables the operator to switch to any one of the 23 CB channels.

Designated the 23/S-Nine, the transmitter also

features a new built-in standing-wave indicator, modern silicon rectifiers for low operating temperatures, speech clipper and splatter filter for balanced modulation, and push-to-talk microphone with removable front-panel control. The transmitter has been specially designed as a companion unit to the company's R-2700 CB receiver.

SELECTIVE CALLING UNIT

29 Allison Electronics Incorporated is now marketing its "Tone-Call" system which provides additional operating features for existing base stations and mobile two-way radio facilities. The unit is designed to be incorporated into all types of two-way equipment.

According to the company, the new system eliminates annoying co-channel interference from other stations which affect base-station units. It also permits the base station operator to "blow the horn" on each mobile radio car to signal the driver if he is away from his unit. It also features a "call-in" indicator lamp at the base station to show which mobile unit is calling the office.

CRYSTAL SWITCHER

30 Regency Electronics Inc. is marketing a new crystal switcher which increases the available transmitting channels from two to six on its Model CB-27 CB transceivers. The Model CS-6 provides instantaneous push-button selection, eliminating the need to switch through other channels to reach the desired frequency.

The unit attaches readily to either fixed or mobile versions of the transceiver. It may also be used with any other CB transceiver to add crystal-controlled receiving channels. The case measures 6¼" x 3" x 1¼".

SSB TRANSMITTER KIT

31 Heath Company has just introduced an SSB transmitter in kit form as the "Marauder." Coverage is 80 through 10 meters with all crystals supplied with the kit. All of the requisite

(Continued on page 102)

power supplies are built in and the unit operates either upper or lower sideband, c.w., AM, and frequency-shift keying. Peak-envelope-power is 180 watts on SSB and c.w., 80 through 10 meters. Unwanted sideband suppression is 55 db while carrier suppression is 50 db.

The circuit is equipped with a multi-section, hermetically sealed crystal bandpass filter and a dual-conversion, crystal-controlled heterodyne oscillator.

A free schematic diagram of the new transmitter is available on request.

HAND-HELD CB TRANSCEIVER

32 **The Hallicrafters Co.** has introduced a fully transistorized, hand-held CB transceiver as the "Littlefone" Model CB-4. Featuring rugged construction, the unit is designed for use between field, mobile, or base stations. It has an average range of two miles.

The CB-4 is housed in a two-tone black and gray case which measures 8" x 3⅜" x 1⅞". Weight is 1½ pounds. Both crystals and transistors are plug-in so no soldering is required for changing channels or servicing. The circuit uses 7 transistors and 1 diode. Power input is 100 mw, making it license-free. Receiver sensitivity is 1 μv. The antenna extends to 38 inches.

MANUFACTURERS' LITERATURE

CAPACITOR REPLACEMENTS

33 **Sprague Electric Company** has announced publication of a second edition of its "Electrolytic Capacitor Replacement Manual." Including 221 set manufacturers from Admiral to Zenith, Manual K-105 covers TV sets as well as home, auto, and portable radios manufactured from 1947 through July 1961.

This 36-page manual lists original part numbers for each manufacturer, followed by ratings, recommended Sprague replacements, and list prices. Over 2450 electrolytics are included to insure exact replacements.

EPITAXIAL TRANSISTORS

34 **General Instrument Semiconductor Division** has issued an 8-page brochure on silicon planar epitaxial transistors. Known as Bulletin PE-15, the new publication covers in detail the production and advantages of planar passivated epitaxial devices.

In addition to describing the characteristics of planar epitaxials, the brochure also provides curves on performance test results and storage life reliability tests.

RELAY DATA

35 **Hi-G, Inc.** has made available a new 40-page catalogue No. 861 which features a standard line of balanced armature relays, solid-state timing modules, fixed-delay and adjustable-delay electronic time-delay relays, voltage sensors, and a customer-designed line of electronic packages or assemblies.

All catalogue items are presented with complete electrical and environmental specifications, electrical diagrams, and drawings of header and enclosure styles available.

COMPUTER CONTROL

36 **Thompson Ramo Wooldridge** is offering a new brochure entitled "Computer Control for Industry" which details the firm's experience and background in supplying computer control systems for industrial applications. These applications include existing installations in the cement, petroleum, chemical, petrochemical, nuclear, missile, television, and other installations.

Also included in the 8-page brochure are installations engineered for the electric power generating and steel industries.

ROTARY SWITCH BROCHURE

37 **Markite Corp.** has announced the availability of a four-page illustrated folder covering its new line of conductive plastic precision rotary switches.

The brochure lists construction features of the switches as well as typical applications. In addition, performance characteristics and test results are graphically represented by means of a comprehensive chart and scope traces.

A.C. MOTOR DATA

38 **Kearfott Division** has just published a four-page data sheet providing pertinent data on its line of general-purpose a.c. motors.

In addition to presenting basic design data, special environmental features, and typical motor-drive applications, specifications on a variety of models are listed in tabular form for speedy reference. A dimensional diagram of typical fan-cooled enclosed a.c. motors is also appended.

LABORATORY INSTRUMENTS

39 **Empire Scientific Corp.** has issued a 12-page bulletin covering its line of precision instruments for laboratory applications.

Included in this two-color publication are details on gaussmeters, plategage, demagnetizers, hydrophones, and sonar transducers. Complete specifications, special features, photographs and descriptions are provided on each unit.

TRANSISTOR REPLACEMENTS

40 **Semitronics Corp.** has issued a new chart listing approximately 2000 transistor types and the firm's suggested replacements.

The chart includes those transistor types most commonly used in TV, radio, high-fidelity, auto, and home entertainment equipment. A special feature of the chart is a section devoted to the company's American-made replacements for Japanese and other foreign-made transistors.

The chart, which measures 17" x 22", can be wall mounted if desired as it is printed on one side of a sturdy paper stock.

HEADERS & MODULES

41 **Joseph Waldman & Sons' Epoxy Products Division** is currently distributing copies of its information bulletin #2 which describes nineteen different electronic headers and module packages.

A wide variety of pin configurations and module shapes are illustrated with photographs and engineering drawings. Electrical and mechanical characteristics of four different plastic materials are listed in a table to help the engineer select the proper material for his particular application.

SOLID-STATE COUNTER

42 **Computer Measurements Company** has issued a single-page data sheet which supplies pertinent details on its 726B solid-state counter along with a complete listing of its sales engineering representatives both in the United States and abroad.

STOCK RELAY CATALOGUE

43 **Potter & Brumfield** has issued a new 10-page catalogue which lists more than 40 standard relays with 500 variations of basic types. Included

in the new issue are descriptions, specifications, and prices on the firm's recently announced series of mercury-wetted contact relays as well as full details on power, general-purpose, plate-circuit, and sensitive relays.

PLUG-IN CONSTRUCTION KITS

44 **Alden Products Company** is offering a 12-page catalogue which describes an extensive line of plug-in construction kits which permit the assembly of a wide variety of prototype and production items.

Included are terminal card mounting system, basic chassis system, experimental breadboard assortment, breadboard/prototype assortment, a rack module and instrument assortment, instrument cases, etc.

SIGNAL TRACER DATA

45 **Don Bosco Electronics, Inc.** has issued a two-color, single-page catalogue sheet covering its "Stethotracer"—a multi-purpose, self-contained signal tracer for troubleshooting defective circuits and electronic components in radios, audio circuits, and electronic equipment.

CB EQUIPMENT BROCHURE

46 **Browning Laboratories, Inc.** has issued a six-page, two-color brochure which carries descriptive information and complete specifications on the firm's new CB transmitter, the Model 23/S-Nine. Also included in the brochure is a self-contained order form and detailed information about the firm's four different purchase plans.

NUCLEAR INSTRUMENTATION DATA

47 **General Electric Company** has issued three new single-page data sheets covering nuclear electronic instrumentation. Bulletin GEC-1616 contains construction and application data and detailed specifications on a high-voltage power supply for precision performance with primary nuclear detectors.

Bulletin GEC-1619 provides detailed specifications on a log count rate meter while Bulletin GEC-1721 provides information on a versatile flux amplifier which provides reactor power level data for visual display, recording or logging, control and shutdown or scram operations.

SERVICE TOOL DATA

48 **Xcelite, Inc.** has just issued a single-page bulletin which illustrates and describes a specially designed terminal wrench for removing spanner nuts on the external antenna and earphone jacks of imported transistor radios. Specifications are given for the tool in two different sizes.

PC SUPPLEMENT

49 **Lafayette Industrial Electronics Division** has issued a four-page printed-circuit supplement which lists a wide variety of components for prototype breadboarding and production. Included is a series of clad and unclad boards, Vector boards of various types, epoxies, printed-circuit kits, miniature irons, thermoplastic hook-up wire, solder components, etc.

POWER TETRODE DATA

50 **Microdot Inc.** is offering a single-page data sheet, Bulletin PTM-1, which describes in detail a new series of high-power tetrode modules which can be furnished as individual units or designed into a complete transmitter.

SILICON POWER TRANSISTORS

51 **Westinghouse's Semiconductor Department** is offering a 12-page technical data bulletin covering its 30-ampere silicon power transistors. The booklet, illustrated with over thirty charts and graphs, describes the electric characteristics, test circuits, and peak pulse power capabilities.

CONDENSED TUBE CATALOGUE

52 **Litton Industries' Electron Tube Division** has issued a 24-page, illustrated condensed catalogue featuring 65 new products. Quick reference specifications and photographs describe most of the company's unclassified microwave tubes and display devices.

INTERCHANGEABILITY GUIDE

53 **Tung-Sol Electric Inc.** is now offering copies of its comprehensive "Interchangeability Guide for Industrial and Special Purpose Electron Tubes."

The 16-page publication lists by number and manufacturers' prefix, the tube type, the Tung-Sol industrial designation, and special-purpose replacement. All replacements can be made without socket or wiring changes.

HALL EFFECT DEVICES

54 **Instrument Systems Corporation** is offering a new bulletin describing Hall effect devices, their applications, and specifications. The four-page booklet condenses data on more than 25 Hall generators sensitive to magnetic flux. The literature discusses measurement and control of magnetic fields ranging from a fraction of 1 gauss to over 30 kilogauss.

LADDER FILTERS

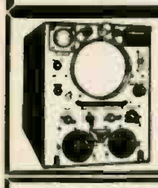
55 **Clevite Electronic Components** has issued a single-page data sheet covering its line of ceramic ladder filters designed for i.f. stages of quality superhet radio receivers.

The two-color bulletin (No. 94012) carries insertion loss graphs, dimensional diagram, general specifications, and tabular data on ten 455-kc. center frequency models and two types with a 500-kc. center frequency. ▲

LORAN APN-4
FINE QUALITY NAVIGATIONAL EQUIPMENT

Determine exact geographic position of your boat or plane. Indicator and receiver complete with all tubes and crystal.
INDICATOR ID-6B/APN-4, and RECEIVER R-9B/APN-4, complete with tubes. Exc. used ... $49.50
Receiver-Indicator as above. BRAND NEW ... $88.50
INVERTER POWER SUPPLY for Loran. Made by Eclipse—Pioneer Div. INPUT: 24 V DC @ 75 A. OUTPUT: 115 V AC @ 10.5 Amps. 800 cycles. Complete with two connecting plugs BRAND NEW ... $49.50
12-Volt Inverter Power Supply, Like New ... P.U.R.
Shock Mount for above ... $2.95
We carry a complete line of spare parts for above.

LORAN APN/4 OSCILLOSCOPE



Easily converted for use on radio-TV service bench.
LIKE NEW! Less tubes, but including 5" Scope, type 5CPI only ... $14.50

LORAN R-65/APN-9 RECEIVER & INDICATOR

Used in ships and aircraft. Determines position by radio signals from known xmitters. Accurate to within 1% of distance. Complete with tubes and crystal. Exc. used.
Value $1200.00. Our Price ... $79.50
Used, less tubes, crystal and visor, but with 3BP1 C.R. tube ... $29.50
INVERTER POWER SUPPLY. INPUT: 24 V DC. OUTPUT: 115 V AC. 800 cy. BRAND NEW ... $49.50
12-Volt Inverter Power Supply, Like New ... P.U.R.
Shock Mount for above ... $2.95
Circuit diagram and connecting plugs available.
We carry a complete line of spare parts for above.

BC-433 RADIO COMPASS RECEIVER
200 to 1750 Kc in 3 bands, 28 V DC power supply required. Complete with 15 tubes. BRAND NEW ... $21.50

ASB-5 'SCOPE INDICATOR

BRAND NEW, including all tubes, together with 5BP1 'Scope Tube. Originally used in Navy Aircraft RADAR equipment. Easily converted for AC operation.
VALUE $250.00! OUR LOW PRICE ... $15.95

BENDIX DIRECTION FINDERS
For commercial navigation on boats.
MN26Y 150-325 Kc; 325-695 Kc; 3.4-7 Mc. Complete with tubes, dynamotor. BRAND NEW ... $19.50
MN28Y Receiver Control Box ... $ 4.95
MN26C Receiver 150-1500 Kc continuous tuning with 12 tubes and dynamotor. Used ... 18.95
MN26C Receiver as above. BRAND NEW ... 27.50
MN20E Rotatable Loop for above ... 4.95
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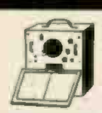
APN-1 FM TRANSMITTER-RECEIVER
420 to 460 Mc Aircraft Radio altimeter equipment. Tubes: 4-955, 3-12SJ7, 4-12SH7, 2-12H6, 1-VR150; Complete with tubes, brand new ... $9.95
APN-1 exc. Used ... $6.95

ARN-5-C AIRBORNE Equipment, to give vertical guidance during landings, 11 tube superhet circuit. Tubes: 28D7, 12SR7, 2-12SN7, 7-6AJ5, Crystal Controlled on 6 channels. Like new ... $12.95

BC-906 FREQ. METER—SPECIAL

Cavity type 145 to 235 Mc. Complete with antenna. Manual and original calibration charts included. BRAND NEW.
OUR LOW PRICE ... $11.88

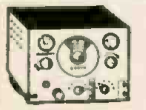
BC-221 FREQUENCY METER



SPECIAL BUY! This excellent frequency standard is equipped with original calibration charts, and has ranges from 125 Kc to 20,000 Kc with crystal check points in all ranges. Excel. Used with original Calibration Book, Crystal, and all tables—LIKE NEW!
Unmodulated ... $72.50 Modulated ... $99.50

BC-638A FREQUENCY METER 100-156 Mc. Xtal controlled. Rack mounting. For 110V AC operation. Less crystals. BRAND NEW ... $29.50

TS-16/APN TEST SET



For aligning and calibration of radio altimeters. May be used to check calibration of count or circuits and modulator sweep freq. and bandwidth of transmitter. Audio-oscillator range: 340 to 7250 cycles. 13/14 V.DC input.
Complete with tubes, connecting cables, instruction summary, BRAND NEW ... $11.95

2 VOLT BATTERY "PACKAGE"

1—2V. 20 Amp. Hr. Willard Storage Battery, Model =20-2. 3" x 4" x 5⅛" high ... $2.79
1—2V. 7 prong Synchronous Plug-in Vibrator ... 1.49
1—Quart Bottle Electrolyte (for 2 cells) ... 1.45
ALL BRAND NEW! Combination Price ... $5.45

WILLARD 6-VOLT MIDGET STORAGE BATTERY

3 Amp. Hour. BRAND NEW. 3⅝" x 1 13/16" x 2⅜". Uses Standard Electrolyte ... Only $2.95

ATTENTION: IMPORTERS-EXPORTERS of ELECTRONIC EQUIPMENT
We specialize in the export of electronic equipment, Parts, and Electronic Tubes at LOWEST prevailing prices. All packing and shipping is made directly from our own warehouses in NYC, to give you substantial savings in handling costs! Your inquiries invited.

BC-603 FM RECEIVER
20 TO 27.9 MC.

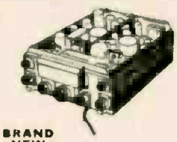
Like new ... $18.95
BRAND NEW ... $22.50
10-channel, pushbutton or continuous tuning. Complete with speaker, squelch, and ten tubes: 3-6AC7, 1-6J5, 3-12SG7, 1-6H6, 1-6V6, 2-6SL7.
EXTRA SET OF 10 TUBES FOR ABOVE brand new in original boxes ... $3.95
FT-237 MOUNTING BASE for BC-603 Revr and BC-604 Xmitter. Brand New ... $5.95
12 or 24V Dynamotor for Above. Exc. Used $4.25 ... Brand New $5.50
BC-683 FM Receiver, 27 to 38.9 Mc. Complete with all tubes. Like New ... $33.33
4-Section Antenna for BC-603, 683 Receivers. Complete with mounting base. BRAND NEW ... $4.95
BC-604 TRANSMITTER—Companion unit for BC-603 Revr above. With all tubes. BRAND NEW ... $6.95
4-Section Antenna for BC-604, 684 Transmitters. Complete with mounting base. BRAND NEW ... $4.95
We carry a complete line of spare parts for above.

SPECIAL! BC-603 FM RECEIVER
CONVERTED FOR FREQ. RANGE 35 to 50 Mc. BRAND NEW! Checked out, perfect working condition, ready for operation. Continuous or Push-button tuning in 35 to 50 Mc. range.
SPECIAL ... $32.50

AC POWER SUPPLY FOR BC603, 683
Interchangeable, replaces dynamotor. Has On-Off Switch. NO RECVR. CHANGE NEEDED. Provides 220 VDC @ 80 Ma. 24VAC @ 2 Amps ... $10.25
Complete 240-page Technical Manual for BC-603, 604 ... $3.15

SCR-522 2-METER RIG!
Terrific buy! VHF Transmitter-receiver, 100-156 Mc. 4 channels, Xtal-controlled. Amplitude modulated voice. They're going fast! Excellent condition. SCR-522 Transmitter-Receiver, complete with all 18 tubes, top rack and metal case.
COMBINATION. Exc. Used ... $29.50
New ... $49.50

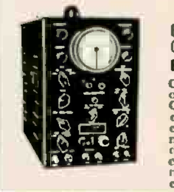
FAMOUS BC-645 TRANSCEIVER
15 Tubes 435 to 500 MC



Can be modified for 2-way communication, voice or code, on ham band 420-450 mc. citizens radio 460-470 mc. fixed and mobile 450-460 mc. television experimental 470-500 mc. 15 tubes (tubes alone worth more than sale price!): 4—7F7, 4—7H7, 2—7E6, 2—6F6, 2—955 and 1—WE-316A. Now covers 460 to 490 mc. Brand new BC-645 with tubes, less power supply in factory carton.
BRAND NEW
Shipping weight 25 lbs. SPECIAL! ... $19.50
PE-101C Dynamotor. 12/24V input ... $7.95
UHF Antenna Assembly ... 2.45
Complete Set of 10 Plugs ... 5.50
Control Box ... 2.25

SPECIAL "PACKAGE" OFFER: BC-645 Transceiver, Dynamotor and all accessories above. COMPLETE, BRAND NEW, While Stocks Last ... $29.50

TS-100AP 'SCOPE



EXC. USED (worth $750) OUR LOW PRICE ... $39.50
Brand New $69.50
Can be used with linear sweep or general purpose test scope. Cables included. Also used with circular sweep as precision range calibrator. Self-contained in metal case 8" x 12½" x 16" deep. For 110 V 50 to 1200 cycles AC. Excellent used, like new, with all tubes including crystals and C.R. Tube.

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BC-312 MOBILE RECEIVER 6 bands, 1500 Kc to 18 Mc. With Tubes and 14 V Dynamotor. Like New $72.50
BC-314 RECEIVER 150-1500 Kc Continuous Tuning, 4-band, for 14 V DC operation. Like New ... $59.50
BC-342 RECEIVER 1.5 to 18 Mc. AC only. Excellent Used ... $72.50
BC-348 SUPERHET RECEIVER 200 to 500 Kc and 1.5 to 1800 Mc. Voice, Tone, CW. Self-contained dynamotor for 24V DC. Like New ... $79.50
ARW-26 RADIO REMOTE CONTROL RECEIVER 60 to 73 Mc carrier freq. Battery operated. Less Batts. Includes tubes: 9002, 9003, 7-3Q4s. Brand New $9.95
AN/APT-5 AIRBORNE RADAR SET, with tubes. Like New ... $49.50
AN/PRC-6 WALKIE-TALKIE Transceiver with external connected handset, for FM voice communication from 47 to 55.4 Mc. 43 channels (1 preset). Operating range 1.5 miles. Uses dry battery. Complete. Like New, less batt. ... Each $88.50

TG-34A KEYER, exc. used, like new ... $21.50
Tape for above, each $1.85. Set of 15, P.U.R.

SCHEMATIC DIAGRAMS For most equipment on this page, each 65c

Please include 25% Deposit with order—Balance C.O.D., or Remittance in Full. 50c Handling Charges on all orders under $5.00. All shipments F.O.B. Our Warehouse, N.Y.C. All Merchandise subject to Prior Sale and Price Change.

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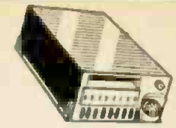
ARC-3 RECEIVER!



Complete with All Tubes Exc. Used ... $16.95
Like NEW ... $21.50
Used ... $14.95
Crystal-controlled 17-tube superhet, tunes from 100 to 156 MC., AM., on any 8 pre-selected channels. 28-volt DC power input. Tubes: 1-9002, 6-6AK5, 1-12SH7, 3-12SG7, 1-9001, 1-12H6, 2-12SN7, 1-12SL7, 1-12A6.

ARC-3 TRANSMITTER
Companion unit for above, tunes 100 to 156 MC on any 8 pre-selected channels. 9 tubes, crystal controlled, provides tone and voice modulation. 28V DC Power input. Complete with all Tubes: 3-6V6, 2-832A, 1-12SH7, 1-6J5, 2-6L6. Exc. Used ... Only $16.95
Like new condition ... $26.50
ARC-3 PUSHBUTTON CONTROL BOX ... $5.95

R77/ARC-3 RECEIVER POWER SUPPLY
Operates from 110 V 60 cycle AC. OUTPUT: 275 V DC @ 150 Ma., and 12.6 V AC @ 4 Amps. Complete power supply includes transformer, choke, capacitor, switch, pilot light, line fuse, 5Y3GT Tube, punched chassis, wiring diagram. Weight 12 lbs. COMPLETE KIT OF PARTS ... $15.00
Wired, Tested, Ready to operate ... $19.95

AN/ART-13 100-WATT XMTR
11 CHANNELS
200-1500 Kc
2 to 18.1 Mc
$69.50 exc. used

Complete with Tubes

Famous Collins Autotune Aircraft Transmitter, AM, CW, MCW. Quick change to any of ten preset channels or manual tuning. Speech amplifier/clipper uses carbon or magnetic mike. Highly stable, highly accurate VFO. Built in Xtal controlled calibrator. PP811s modulate 813 in final up to 90%, class "B." A Real "HOT" Ham buy at our low price! Orig. cost $1800.
AN/ART-13 XMTR as above, Like New ... $69.50
0-16 Low Freq. Osc. Coil for ART-13 ... 7.95
24V Dynamotor for ART-13 ... 11.95
Same as above less meter ... 39.50
We carry a complete line of spare parts for above.

SCR-274 COMMAND EQUIPMENT
ALL COMPLETE WITH TUBES

Type	Description	Used	Like NEW
BC-453	Receiver 190-550 KC	$12.95	$14.95
BC-454	Receiver 3-6 Mc	10.45	12.45
BC-455	Receiver 6-9 Mc	11.50	13.95
Marine Receiver	1500-3000 KC Brand New		$16.95

110 volt AC Power Supply Kit, for all 274-N and ARC-5 Receivers. Complete with metal case, instructions ... $7.95
Factory wired, tested, ready to operate ... $11.50
SPLINED TUNING KNOB for 274-N and ARC-5 RECEIVERS. Fits BC-453, BC-454 and others. Only ... 49c
BC-457 TRANSMITTER—4-5.3 Mc. complete with all tubes and crystal, BRAND NEW ... $9.75
BC-458 TRANSMITTER—5.3 to 7 Mc. Complete with all tubes and crystal. BRAND NEW ... $9.75
T19 TRANSMITTER ¾ m.c. complete with all tubes and crystal. Exc. Used ... $9.95
BC-456 Modulator ... USED 3.45 NEW 5.95
MD7 Modulator, Like New ... $9.95
ALL ACCESSORIES AVAILABLE FOR ABOVE

MOBILE-MARINE DYNAMOTOR
Model DM35

Input 12V DC. Output: 625 V DC @ 225 Ma. for press-to-talk intermittent operation. Shpg. wt. 14 lbs.
BRAND NEW ... P.U.R.

OTHER DYNAMOTOR VALUES:

Type	Input	Output	Excellent Used	BRAND NEW
DM-32A	28V 1.1A	250V .05A	2.45	4.45
DM-33A	28V 5A 28V 7A	575V .16A 540V .25A	1.95	3.75
DM-34D	12V 2A	220V .080A	4.15	5.50
DM-53A	28V 1.4A	220V .080A	3.75	5.45
DM-64A	12V 5.1A	275V .150A		7.95
PE-73C	28V 20A	1000V .350A	8.95	14.95
PE-86	28V 1.25A	250V .050A	2.75	3.85

DM-42A DYNAMOTOR, Input 12 V DC @ 39 Amps. Output 515 V DC @ 215 Ma. and 1030 V DC @ 260 Ma. Wt. 38 lbs. BRAND NEW, each ... $6.95
DM-37 DYNAMOTOR, Input 25.5 V DC @ 9.2 A. Output 625 V DC @ 225 Ma. BRAND NEW, Each $3.25

MICROPHONES

Model	Description	EXC. USED	BRAND NEW
T-17	Carbon Hand Mike	$4.45	$6.95
RS-38	Navy Type Carbon Hand Mike		4.75

HEADPHONES

Model	Description	Excellent Used	BRAND NEW
HS-23	High Impedance	$2.19	$4.49
HS-33	Low Impedance	2.69	4.59
HS-30	Low Imp. (featherwt.)	.90	1.65
H-16/U	High Imp. (2 units)	3.75	7.95

TELEPHONICS—600 ohm Low Impedance HEADSETS, BRAND NEW, PER PAIR ... $3.25
CD-307A Cords, with PL55 plug and JK26 Jack ... .99
Earphone Cushions for above—pair ... .50

AN/ARN-6 RADIO COMPASS EQUIPMENT
Highly efficient airborne direction finding system. Frequency: 100 to 1750 Kc in 4 bands. 26.5 DC V Power Input. LIKE NEW ... $79.50

SCR-625 MINE DETECTOR
Complete portable outfit in original packing, with all accessories. Brand New $27.50

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ELECTRONICS! Associate degree—29 months. Technicians, field engineers, specialists in communications, missiles, computers, radar, automation. Start February, September. Valparaiso Technical Institute, Dept. N, Valparaiso, Indiana.

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TUBES—TV, Radio, Transmitting And Industrial Types At Sensibly Low Prices. New, Guaranteed, 1st Quality, Top Name Brands Only. Write For Free Catalog or Call WAlker 5-7000, Barry Electronics Corp., 512 Broadway, New York 12N, N. Y.

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GOVERNMENT Surplus Receivers, Transmitters, Snooperscopes, Parabolic Reflectors, Picture Catalog 10¢. Meshna, Malden 48, Mass.

GOVERNMENT Sells Surplus: — Electronics; Oscilloscopes; Transceivers; Test Equipment; Radar; Sonar; Walkie-Talkie; Boats; Jeeps; Aircrafts; Misc.—Send for "U.S. Depot Directory & Procedures"—$1.00—Brody, Box 425(RT), Nanuet, New York.

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PRECISION Resistors, carbon-deposit. Guaranteed 1% accuracy. Millions in stock. ½-watt, 8¢. 1-watt, 12¢. 2-watt, 15¢. Leading manufacturer. Rock Distributing Co., 902 Corwin Rd., Rochester 10, N.Y.

SAVE dollars on radio, TV-tubes, parts at less than manufacturer's cost. 100% guaranteed! No rebrands, pulls. Request Bargain Bulletin. United Radio, 1000-W, Newark, N.J.

ELECTRONIC IGNITION, Transistorized Improved performance, saves gas, tuneups. Coils, Kits Conversions Literature. Palmer Electronics, Carlisle, Massachusetts.

SUPERSENSITIVE Directional microphone picks up a whisper at great distances. Used by investigators to record faint sounds without being detected. Easily constructed for about $7. Step by step plans, $1.95. Dee Company, Box 7263-D, Houston 18, Texas.

CONVERT any television to sensitive big-screen oscilloscope. Only minor changes necessary. Plans $1.95. Relco, Box 10563, Houston 18, Texas.

INVESTIGATORS, write for free brochure on latest subminiature electronic listening devices. Dept. 4B, 11500 NW 7th Ave., Miami 50, Fla.

INDUSTRIAL Tubes Type 5555 $95.00 — CRT 7MP7 $10.00—ELC-6-A $6.00. Many others; write your requirements. Spera Electronics, 37-10 33st. L.I.C. N.Y.

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ELECTRONIC switches. Heathkit S-2, Eico 488, $14.00; Variac 7.5 amps. $15.00—Pollock, Little Silver, New Jersey.

TRANSISTORIZED Products Catalog, dealers prices, $1.00. Intercontinental, CPO 1717, Tokyo, Japan.

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"FREE—R.C.A., G.E. etc tubes catalog. Discount to 75% from list. Picture tubes at 75¢ inch up. Parts, parts kits at 1/10 original cost. Needles, tube testers, silicons, seleniums, 7" TV bench test tube: $6.99—and more." Arcturus Electronics Corp., EW, 502, 22nd Street, Union City, New Jersey.

CONVERT any Television to Color. Send $2.98 and size —Millers, 874 Ledro Street, Cincinnati 46, Ohio.

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QUICKSILVER, Platinum, Silver, Gold. Ores Analyzed. Free Circular. Mercury Terminal, Norwood, Massachusetts.

CASH Paid! Sell your surplus electronic tubes. Want unused, Clean radio and TV receiving, transmitting special purpose, Magnetrons, Klystrons, broadcast types. Want military and commercial lab/test equipment such as G.R.H.P., AN/UPM prefix. Also want commercial Ham Receivers and Transmitters. For a Fair Deal write: Barry Electronics Corp., 512 Broadway, New York 12, N. Y. (Walker 5-7000).

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USED Power Supply. Input; 220 Vac, 60 cycle, Single Phase. Output; 28 VDC @ 75 to 100 amperes. Contact Connecticut School of Electronics, 586 Boulevard, New Haven, Connecticut.

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RENT Stereo Tapes—over 2,500 Different—all major labels—free catalog. Stereo-Parti, 811-G, Centinela Ave., Inglewood 3, California.

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Answer to "Math Puzzlers" appearing on page 79

1. First calculate the times at which the minute and hour hands are exactly 120 degrees or 1/3 circle apart. Then calculate the position of the second hand at these times, and choose those times when the difference between the hour and minute hands is closest to 120 degrees. The closest difference is 4/11 (.3636) circle at T = 9-1/11 hours and T = 2-10/11 hours. So the answer is 2 hours, 54 minutes, 35 seconds. The only other time could have been 9 hours, 5 minutes, 25 seconds.

2. Let AT and BT be the tangents, ACB the arc, O the center, OA the radius. Let angle AOT = x and AO = r. Then arc ACB = $(2\pi - 2x)\ r = 1$, and $\tan x = 1/r$; whence $\tan x = 2\ (\pi - x)$. By approximation: x = 74 degrees 46.2 minutes. r = 1 mile/tan x = 5280 feet/tan x = 1437.45 feet.

3. Let M = my age in years, S = son's age, and F = father's age. My father is five times as old as my son, therefore: F = 5S. When I am as old as my father, my son will be F — M years older than he is now; his age then will be S + F — M. Since this is 8 years more than my present age, S + F — M = M + 8. The third equation is: F + M = 100. Solving these equations gives S = 13, and hence M = 35 and F = 65.

4. If the prisoner places one white ball in one box and the remaining balls (9 white and 10 black) in the other box, his chance of survival would be (1 + 9/19)/2 = 0.737 or 73.7%.

5. Only one man, Methuselah, who attained the record age of 969 years. Solving the equation $2^{3217} = 10^x$, we have $x = 3217 \log 2 = 968.4$. The number of digits in $2^{3217} - 1$ is one more than the integral part of x or 969.

6. He divides the bricks into 3 groups of 3, 3, and 2 bricks. Then he weighs the 2 sets of 3 bricks against each other. If they balance, then the heavier brick is in the group containing 2 bricks which another weighing will simply tell. If they do not balance, then he weighs two of the group that was heavier on the first weighing. If these two balance, then the heavier brick was set aside. If they do not balance, then the scales tell which is the heaviest brick.

7. The time must have been 43-7/11 minutes past 2 a.m.

8. 100 miles, since the odometer reading now must be x9899.9 where x is any digit from 0 to 9. ▲

Answer to ELECTRONIC CROSSWORDS (Appearing on page 81)

		T	W	I	N	■	■	■	P	O	R	T		
		R	A	C	E	■	■	■	F	R	E	E		
D	R	I	V	E	■	E	M	F	■	E	X	T	R	A
R	O	P	E	■	B	R	O	A	D	■	■	E	I	A
A	T	■	■	I	O	N	■	R	A	Y	■	■	G	A
G	A	L	E	N	A	■	N	A	V	E	■	A	S	■
■	R	O	C	K	■	■	E	D	I	S	O	N	■	■
■	Y	A	H	■	A	R	O	S	E	■	P	O	T	■
■	■	D	O	T	G	E	N	■	■	F	A	D	E	■
R	P	S	■	R	I	P	S	■	A	L	L	E	N	S
A	H	■	■	I	N	E	■	S	T	Y	■	■	D	C
C	O	L	D	■	G	A	T	E	■	■	I	D	E	A
K	N	E	E	S	■	T	O	T	■	A	C	O	R	N
		A	C	I	D	■	■	■	F	L	A	G		
		D	I	S	C	■	■	■	M	A	S	S		

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TV, Radio Output Drops in November

FIGURES compiled by the Marketing Data Department of the Electronic Industries Association indicate that television set production in November 1961 declined to a total of 582,952, compared with the 620,815 recorded for October.

The total number of TV sets produced during January-November 1961 maintained a precarious lead over the same period for 1960. Totals were 5,597,535 through November 1961 compared with 5,302,877 through November 1960.

Total November radio production was set at 1,730,761, some 66,000 sets under the 1,796,391 receivers produced in October. Cumulative output of radio receivers through November totaled 15,528,610. The total for the same period in 1960 was 15,604,794.

Radio and TV production for the period January through November 1961 is listed in the table below. ▲

	Total TV	TV with U.H.F.	Total Radio	Auto Radio	FM Radio
November	582,952	42,743	1,730,761	588,343	125,184
October	620,815	43,198	1,796,391	576,529	95,318
September	694,580	51,253	2,048,698	591,493	110,174
August	514,674	33,946	1,385,101	451,374	69,090
July	383,378	23,233	1,030,399	320,128	48,114
June	615,118	34,641	1,626,263	518,010	88,808
May	470,399	22,782	1,196,949	408,875	49,705
April	405,808	19,085	1,124,924	375,570	51,260
March	497,458	21,540	1,384,052	384,227	75,044
February	444,418	24,514	1,115,029	307,973	41,357
January	367,935	25,270	1,090,073	387,136	50,421
Total to 11/30/61	5,597,535	332,205	15,528,640	4,909,658	804,475
Total to 11/30/60	5,302,877	405,838	15,604,784	5,911,305	852,329

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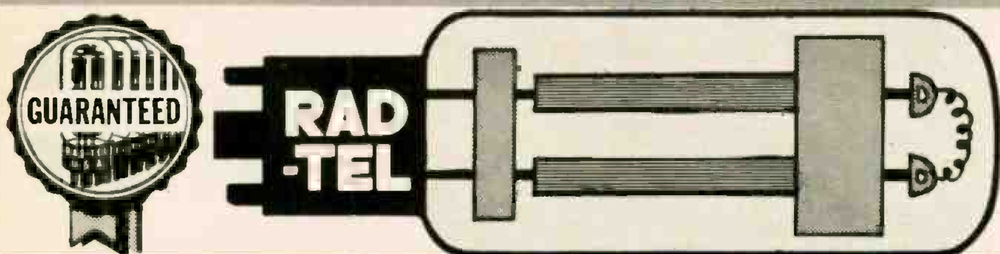

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0Z4	.79	5CL8	.76	6BJ7	.79	6EY6*	.75	12AE6	.43	12EN6	.78	19C8	1.14
1AX2	.62	5CM8*	.90	6BK7	.85	6F5GT	.39	12AE7	.94	12EZ6	.53	19T8	.80
1B3	.79	5CQ8	.84	6BL7	1.00	6FE8	.75	12AF3	.73	12F8	.66	21EX6	1.49
1DN5	.55	5CZ5*	.72	6BN4	.57	6GH8	.80	12AF6	.49	12FA6	.79	25AV5	.83
1G3*	.79	5EA8	.80	6BN6	.74	6GK6*	.79	12AJ6	.46	12FM6	.43	25AX4	.70
1J3*	.79	5EU8	.80	6BQ6	1.05	6GN8*	.94	12AL5	.45	12FR8	.91	25BK5	.91
1K3*	.79	5J6	.68	6BQ7	1.00	6H6	.58	12AL8	.95	12FX8	.85	25BQ6	1.11
1R5	.62	5T8	.81	6BS8	.90	6J5GT	.51	12AQ5	.60	12GC6	1.06	25C5	.53
1S4	.59	5U4	.60	6BU8	.70	6J6	.67	12AT6	.43	12J8	.84	25CA5	.59
1S5	.51	5U8	.81	6BX7	1.02	6K6	.63	12AT7	.76	12K5	.65	25CD6	1.44
1T4	.58	5V3	.90	6BY5	1.15	6L6	1.06	12AU6	.51	12L6	.58	25CU6	1.11
1U4	.57	5V6	.56	6BY6	.54	6N7	.98	12AU7	.60	12SA7	.92	25DN6	1.42
1U5	.50	5X8	.78	6BY8	.66	6S4	.51	12AV6	.41	12SF7	.69	25EH5	.55
1X2B	.82	5Y3	.46	6BZ6	.55	6SA7GT	.76	12AV7	.75	12SH7	.49	25L6	.57
2AF4	.96	6A8G	1.20	6BZ7	1.01	6SG7GT	.41	12AX4	.67	12SJ7	.67	25W4	.68
2BN4	.64	6AB4	.46	6BZ8	1.09	6SH7GT	.49	12AX7	.63	12SK7	.74	32ET5	.55
2EN5*	.45	6AC7	.96	6C4	.43	6SJ7	.88	12AY7	1.44	12SL7	.80	32L7	.90
3AL5	.42	6AF3	.73	6CB6	.55	6SK7GT	.74	12AZ7	.86	12SN7	.67	35B5	.60
3AU6	.51	6AF4	.97	6CD6	1.42	6SL7GT	.80	12B4	.63	12SQ7	.78	35C5	.51
3AV6	.41	6AG5	.68	6CE5*	.57	6SN7GT	.65	12BA7	.84	12U7	.62	35L6	.57
3BA6	.51	6AH4	.81	6CF6	.64	6SQ7	.73	12BD6	.50	12V6	.53	35W4	.42
3BC5	.54	6AH6	.99	6CG7	.61	6T4	.99	12BE6	.53	12W6	.69	35Z5	.60
3BE6	.52	6AK5	.95	6CG8	.77	6T8	.85	12BF6	.44	12X4	.38	36AM3*	.36
3BN6	.76	6AL5	.47	6CK4*	.70	6U8	.83	12BH7	.77	17AX4	.67	50B5	.60
3BU8	.78	6AM8	.78	6CL8	.79	6VG6T	.54	12BK5	1.00	17BQ6	1.09	50C5	.53
3BY6	.55	6AQ5	.53	6CM6	.64	6W4	.60	12BL6	.56	17DQ6	1.06	50EH5	.55
3BZ6	.55	6AR5	.55	6CM7	.66	6W6	.71	12BQ6	1.06	17W6	.70	50L6	.61
3CB6	.54	6AS5	.60	6CM8*	.90	6X4	.39	12BR7	.74	18FW6*	.49	70L7	.97
3CS6	.52	6AS6	.80	6CN7	.65	6X5GT	.53	12BV7	.78	18FY6*	.50	7025	.69
3DG4*	.85	6AT6	.43	6CQ8	.84	6X8	.80	12BY7	.77	18FX6*	.53	807	.70
3DK6*	.60	6AT8	.79	6CR6	.51	7A8	.68	12BZ7	.75	19AU4	.83	117Z3	.61
3DT6	.50	6AU4	.82	6CS6	.57	7AU7	.61	12C5	.56	19BG6	1.39		
3Q4	.63	6AU6	.52	6CS7	.69	7B6	.69	12CN5	.56				
3Q5	.80	6AU7	.61	6CU5	.58	7EY8*	.73	12CR6	.54				
3S4	.61	6AU8	.87	6CU6	1.08	7F8	.90	12CU5	.58				
3V4	.58	6AV6	.41	6CY5*	.70	7N7	.90	12CU6	1.06				
4BQ7	1.01	6AW8	.90	6CY7	.71	7S7	1.01	12CX6	.54				
4BZ7	.96	6AX4	.66	6DA4*	.68	7Y4	.69	12D4*	.69				
4BZ8	1.10	6AX5	.74	6DB5	.69	8AU8	.83	12DB5	.69				
4CS6	.61	6AX7	.64	6DB6	.51	8AW8	.93	12DE8	.75				
4DT6	.55	6AX8*	.92	6DE6	.58	8BQ5	.60	12DL8	.85				
5AM8	.79	6BA6	.50	6DG6	.59	8CG7	.62	12DQ6	1.04				
5AN8	.86	6BA8	.88	6DK6	.59	8CM7	.68	12DS7	.79				
5AQ5	.52	6BC5	.61	6DN6	1.55	8CN7	.97	12DT5*	.76				
5AS8*	.86	6BC7	.94	6DQ6	1.10	8CS7	.74	12DT7*	.79				
5AT8	.80	6BC8	.97	6DT6	.53	8CX8	.93	12DT8*	.79				
5AV8	1.01	6BD5	1.25	6DT8*	.79	8EB8	.94	12DU7	1.01				
5BC8	.79	6BE6	.55	6EA8	.79	8SN7	.66	12DW8*	.89				
5BE8	.83	6BF5	.90	6EB5*	.72	9CL8	.79	12DZ6	.56				
5BK7	.82	6BF6	.44	6EB8	.94	11CY7	.75	12ED5	.69				
5BQ7	.97	6BG6	1.66	6EM5*	.76	12A4	.60	12EG6	.54				
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APRIL, 1962

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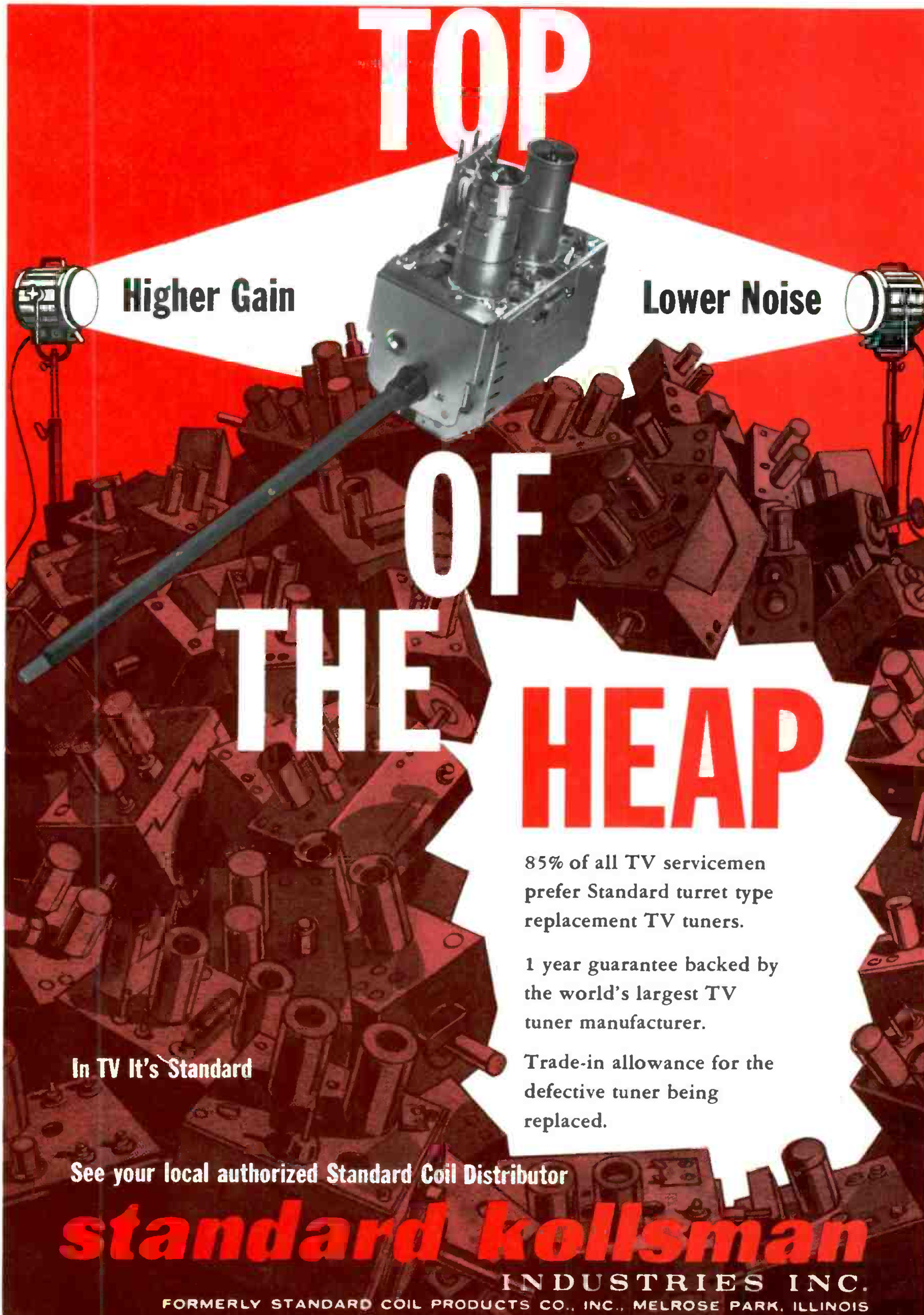
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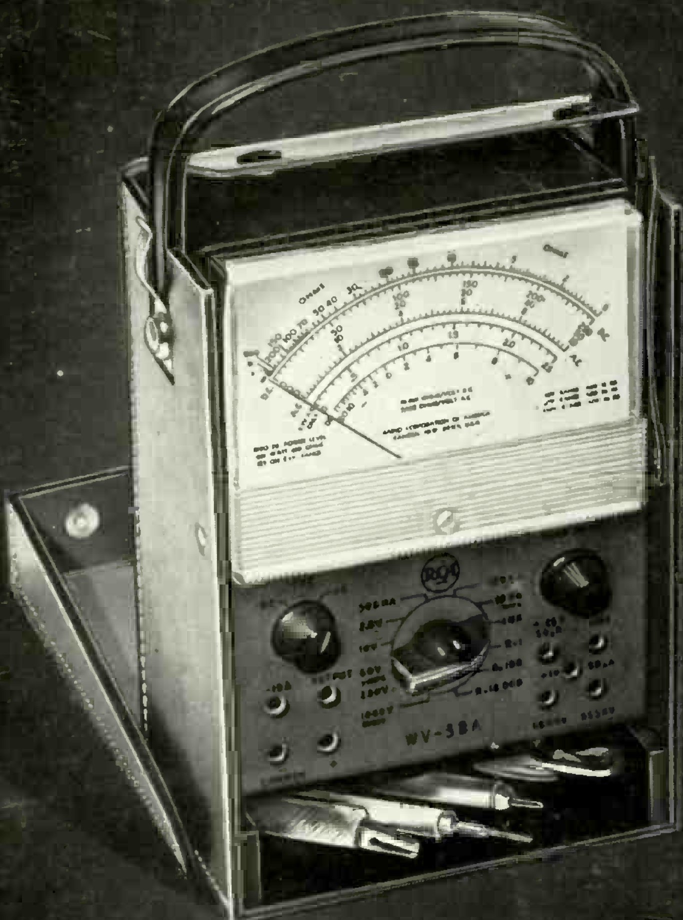

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- Easy-to-read meter measures 5" wide
- Non-breakable, sealed plastic window
- Red test lead has probe and slip-on alligator clip for added versatility

RCA WV-38A available factory-wired and calibrated: $43.95*

ONLY **$29.95***

Attractive, scuff-resistant laminated-vinyl carrying case, $4.95* extra

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Famous VoltOhmyst® quality and performance at a low price! Special test features include: separate 1.5-volt rms and 4-volt peak-to-peak scales for accurate low AC measurements. Tests AC and DC voltages to 1500 volts; resistance from 0.2 ohm to 1000 megohms. Complete with ultra-slim probes, long flexible leads, special holder on handle to store leads.

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Here is a rugged, compact oscilloscope that weighs only 14 pounds. Easily portable for in-the-home or shop troubleshooting. Ideal for servicing black-and-white and color TV, radio, hi-fi components, tape recorders, etc. Ample gain and bandwidth for the toughest jobs. 3" graph-scale screen and internal calibrating voltage source for direct reading of peak-to-peak voltage.

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RCA WV-98B (K)

SENIOR VOLTOHMYST® KIT

A real money and time saver...now available in kit form! The etched-circuit-board and AC/DC ohms probe are pre-assembled. Separate color-coded scales measure DC voltages, 0 to 1500 volts; AC voltages, 0 to 1500 volts rms or 4200 volts peak-to-peak. Resistance from 0.2 ohm to 1000 megohms. 200-microampere meter movement with less than 1% tracking error. Precision multiplier resistors accurate to ± 1%.

ONLY **$62.50***

RCA WV-98B available factory-wired and calibrated: $79.50*

*User Price (Optional)

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