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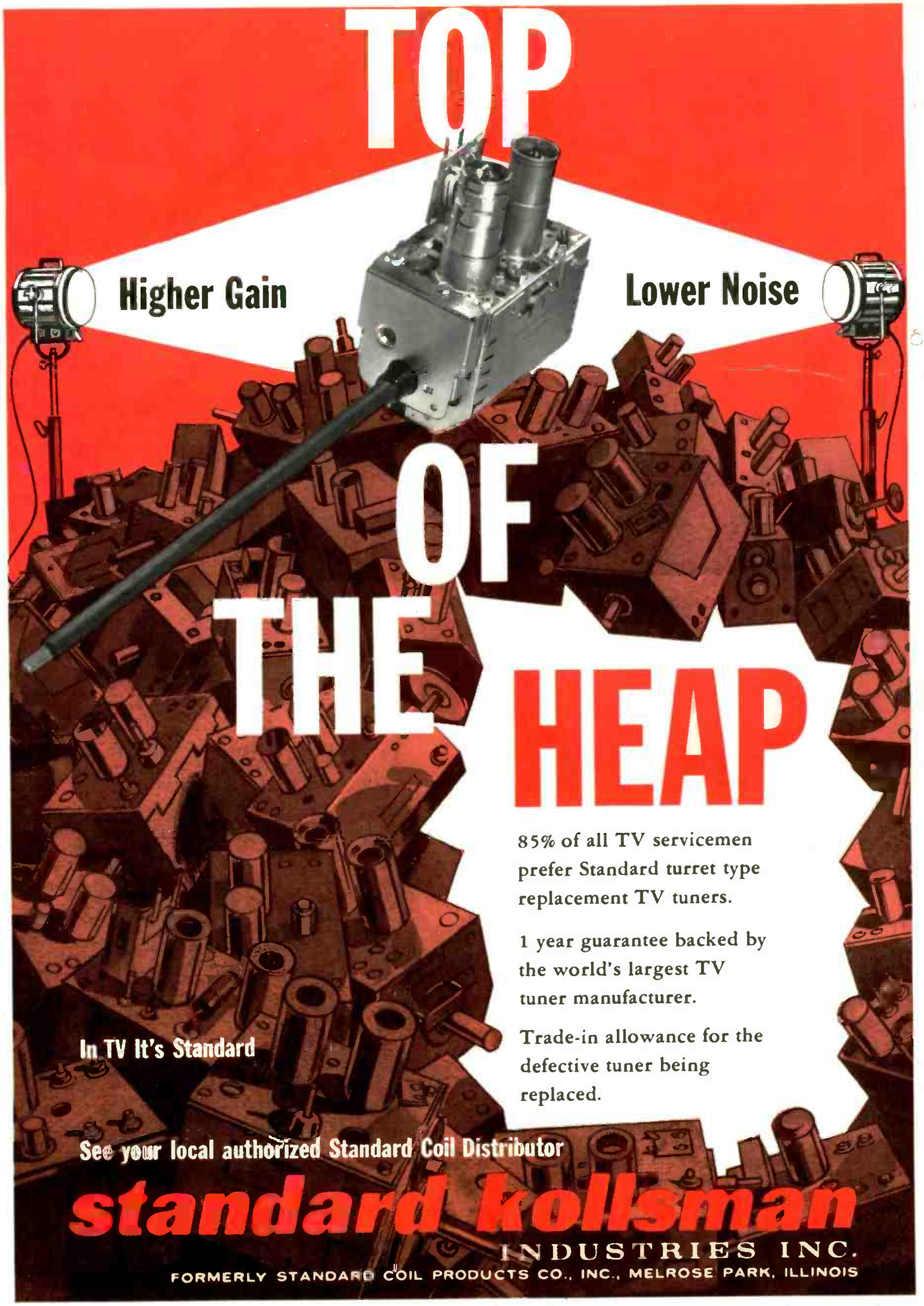
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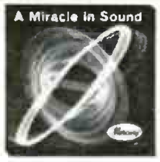

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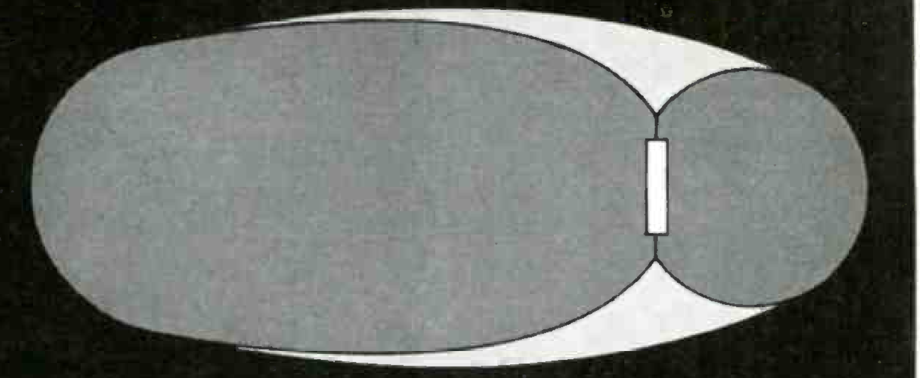

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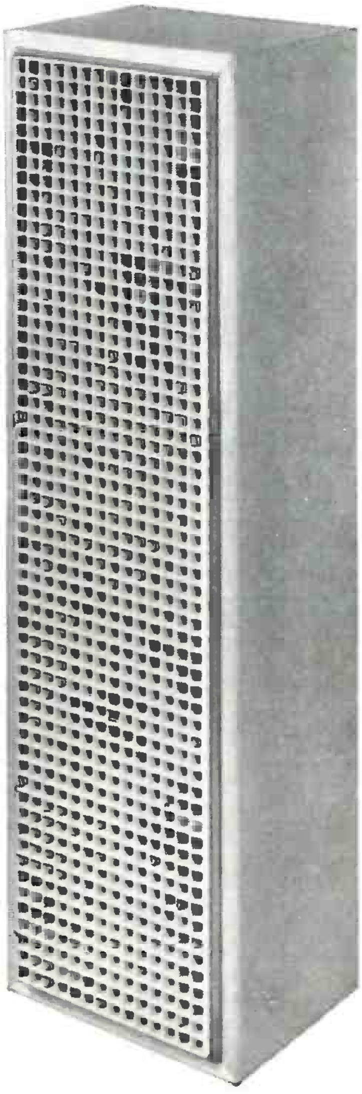

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JANUARY 1962 / VOL. 67 NO. 1 **Electronics World**

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DESIGN OF TRANSISTORIZED CB TRANSMITTERS
Here are three CB transmitter circuits, having modulated r.f. power outputs of 25, 130, and 250 mw., made possible by an inexpensive mesa transistor. Suitable modulator circuits are also included.

ADVANCED TRAINING FOR TECHNICIANS
Experienced technicians who have already had training often find that they need more to get ahead; yet they cannot interrupt their careers to go back to school. Alternate education possibilities in the various areas of electronics are explored.

ELECTRONICS AND BIOLOGY
Electronics is helping us to better understand living things. In turn, biology is helping us to build better computers. Here are some results of this interchange.

PRACTICAL SQUARE WAVES AND GENERATORS
Practical square-wave testing and data interpretation can be thrown off because the test waveforms fail to meet certain requirements. Characteristics of useful square waves, how they are used, and the construction of a generator that meets these requirements are covered.

MINIATURE TRANSISTORIZED SCOPE
Small, lightweight, and battery-operated, this instrument can be constructed to have specifications that make it useful for a wide range of applications.

PULSE-MODULATION TECHNIQUES
Pulses are widely used to transmit data from one point to another. Here is the story of how these pulse systems work and how they are able to carry information.

PIONEER WIRELESS STATION
A bit of nostalgia from an Old Timer, this article recalls the Marconi Wireless' "high-power" Alaska radio station, KPB, —a radio giant of the year 1913—as remembered by one of the station's operators.

TUNNEL DIODE BIAS SUPPLIES
Practical battery and a.c. power supplies to provide measured d.c. parameters needed by technicians and experimenters.

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Kenneth F. Foltz, Broad St., Middletown, Md.	1st	12
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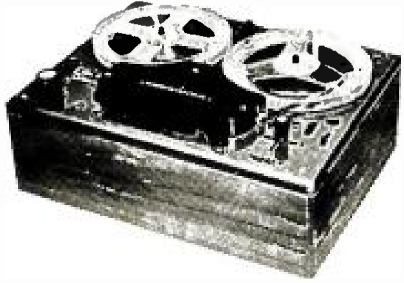

...for the Record

By **W. A. STOCKLIN**
Editor

MORE ON THE ELECTRONICS "TECHNICIAN"

OUR plea for ideas and suggestions on the editorial "The Electronics 'Technician,'" published in our October 1961 issue, resulted in quite a few interesting comments from our readers. In the main, they complimented us on our attempt to define the electronics technician but, from that point on, they were as divergent in their ideas as one could imagine. Some agreed with us that there are too many engineers performing "technician functions." Others criticized us severely for the emphasis we put on the necessity of having a degree in order to qualify as an engineer. Many felt that the three classifications (design technician, service technician, and operation technician) were insufficient and that others should be added.

One letter written by Alfred Visconti, Test Lab Supervisor at *Colvin Laboratories Inc.* (electro-mechanical instruments), is typical of one point of view. Most of Mr. Visconti's letter is published in the "Letters from Our Readers" column, on page 8 of this issue.

Our first attempt was to break the technician group into three major classifications, knowing that we would not cover some of the areas in which the technician functions. We purposely omitted such classifications as sales, procurement, installation, technical writing, and production-line testing. These are important areas for electronics technicians and, although their total number is small compared to the number of technicians employed in our three major classifications, they should not be omitted. It may be wise for us to extend our classifications to include these individuals.

Regarding a college engineering degree, we did say "We don't feel that it is fair to infringe on an engineering title without the degree and experience to back it up." We should have qualified our remarks and said "without the degree *and/or* experience." This would have been more factual.

We are fully aware that there are many individuals functioning today as engineers and doing actual design and engineering work without having a college degree. These individuals, while they may not have pursued a formal engineering course to a degree, nevertheless are well qualified for their jobs because of their knowledge and experience. We might even go so far as to say that an "engineer" is one who is engaged in the profession of engineering and that a formal degree may or may not be one of the pre-requisites for his job.

On the other hand, there are many companies that strongly emphasize the necessity of having a degree to become a member of their engineering staffs. *Airborne Instruments Laboratory* and *Hazeltine Research Corporation,* for example, insist on this requirement. There are exceptions, of course, but a panel of engineers must pass on qualifications before an exception is made. It is also interesting to note that *Bell Telephone Laboratories,* for the most part, even ignores the title of "engineer" in that members of their engineering department are referred to as "members of the technical staff."

In areas other than research, development, and original design, a degree is not usually a basic requirement. Emphasis is on practical experience, with a knowledge of math and physics, for example, being of less importance. The engineer's functions in this area are extremely varied but, for the most part, they are involved in consumer products and services. This was basically the electronics industry prior to World War II.

Since World War II the growth and future, however, have been in research and development. These are the areas we were thinking about in our October 1961 editorial. An engineer functioning in this area today would have been considered a scientist 20 years ago. The engineering profession is rising higher and higher in level and it is, therefore, imperative that an engineer have as thorough a knowledge of all of the sciences as possible. As time goes on these engineers may even find that a BS degree is not sufficient and that a Master's degree may become a basic requirement.

We are fully aware of the fact that a degree in itself has no meaning and, in essence, is simply a certificate to indicate that a student has passed certain courses. It is the knowledge that he has gained that is important. If a person obtains an equivalent amount of knowledge by self-education, special courses, etc., then such a person should be able to make just as great a contribution to our technology as the graduate engineer.

Times have changed and will continue to do so. Our society is becoming more technological every day. This means that the role of the technical person, be he engineer or technician, is becoming more important and this role will continue to grow in importance as time goes on. ▲

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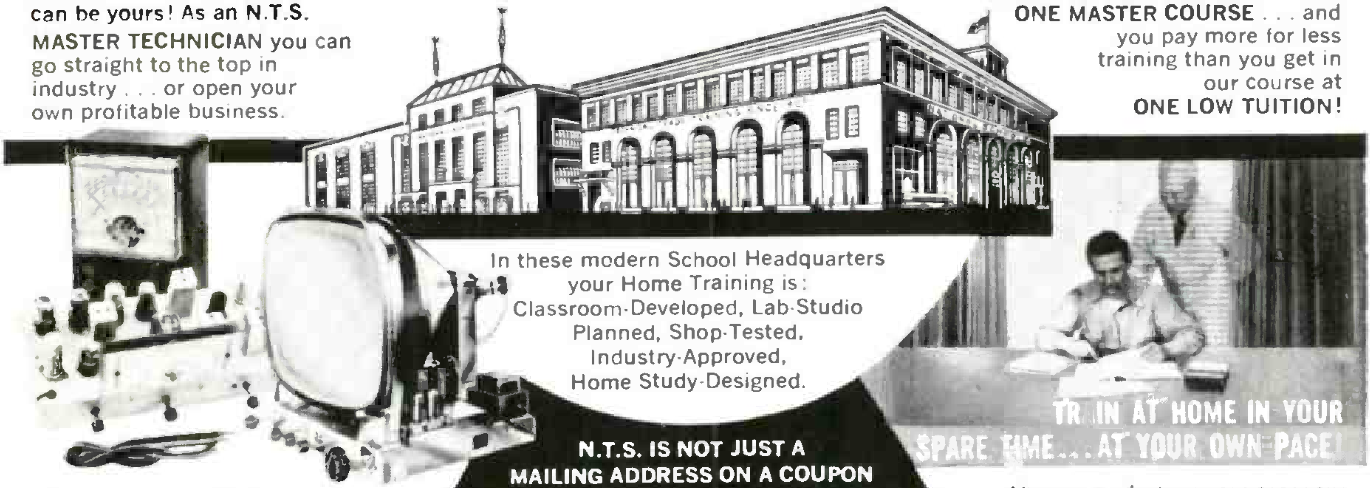

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LETTERS FROM OUR READERS

THE ELECTRONICS "TECHNICIAN"

To the Editors:

The editorial, "The Electronics 'Technician,'" in the October issue of ELECTRONICS WORLD, proved to be extremely interesting.

Your attempt to eliminate any prevailing confusion within the industry by defining and subdividing all persons termed as technicians, associate engineers, lab assistants, etc. into neatly defined categories is to be commended, but in the process you seem to have overlooked a number of contributing factors, which may help to bring the subject more clearly into focus.

One of these factors is the definition for a man who is engaged in actual design of electronic equipment, services and maintains highly complex electronic equipment, and operates such equipment. A definition of this man would most certainly be lacking if measured by your present standards. Numerous people filling these job categories who are presently employed by hundreds of companies throughout this country, would find themselves in an undefined job position due to a lack of college education, or an incomplete one.

You mentioned that it would be unfair to what you term "infringe on an engineering title without the degree and experience to back it up," and by so doing placed the college degree as being more important than the individual's potential. By your own definitions, this would automatically rule out thousands of people who graduated at the top of their high-school graduating classes, acquired a few years of college education with outstanding marks, and are presently recognized by engineers, managers, and executives in their respective fields, electronic or otherwise.

In addition, it is worth mentioning that approximately one-third of the most intelligent high-school students do not go on to college. A certain proportion of these people who may have gone into electronics have just as great a capacity for growth as their classmates who have gone on to college and a degree.

Some of these people have a greater potential than others who may have stumbled through college to a degree.

It seems when trying to define the word "technician" by your standards, you will have to look at the man, not the degree.

ALFRED VISCONTI
Test Lab Supervisor
Colvin Laboratories, Inc.
East Orange, N. J.

Many of Reader Visconti's points are certainly well taken. For our detailed comments on the above letter see the editorial on Page 6.—Editors.

* * *

ION GENERATOR FOR THE HOME

To the Editors:

Negative ions may well be a "modern miracle" and electrostatic precipitation is a proven method of dust collection, but what is Mr. R. E. Patrie's device in the October, 1961 issue of ELECTRONICS WORLD?

Negative ions are attracted to regions of higher potential. In this case it appears that unless Mr. R. E. Patrie's furnace and ductwork are all plastic the majority if not all of the negative ions generated will be lost to the many square feet of metal ductwork and furnace area. To be effective it would seem that a negative ion generator would be placed in a duct discharge.

As for electrostatic precipitation all designers of industrial precipitators place their collecting plates downstream of the ionizing wires or parallel to the wires and to the gas flow. In Mr. R. E. Patrie's precipitator, as shown in the first picture on Page 49, the ionizing wires are downstream of the collecting media. Thus either the charged dust particles must flow upstream to the collector grid, which is doubtful, or they will be attracted to the metal surfaces downstream—the centrifugal fan, heat exchanger, and duct work. As soon as the charged particles reach the grounded metal surfaces they will discharge and possibly be swept off and re-entrained into the air stream.

Also, as a matter of semantics, what are "larger ions which have no charge"? An ion *is* a charged particle.

ROBERT L. TWICHELL
Spencerport, New York

Reader Twichell's concluding remark about "larger ions which have no charge" is well taken. We should simply have said "larger ions." In answer to the other remarks here are the author's comments.—Editors.

To the Editors:

The unit described in the article was designed primarily as an ion generator with the additional filtering properties as a secondary feature. In this application, a minimum of obstruction is placed in the path of the ions after they emerge from the ionizer grid. The incoming air goes through the filter then past the ionizer and directly into the intake of the blower. The filtering then takes place as the return air goes through the metal filter.

Where precipitation filtering, rather than ion generation is of prime concern.

(Continued on page 12)

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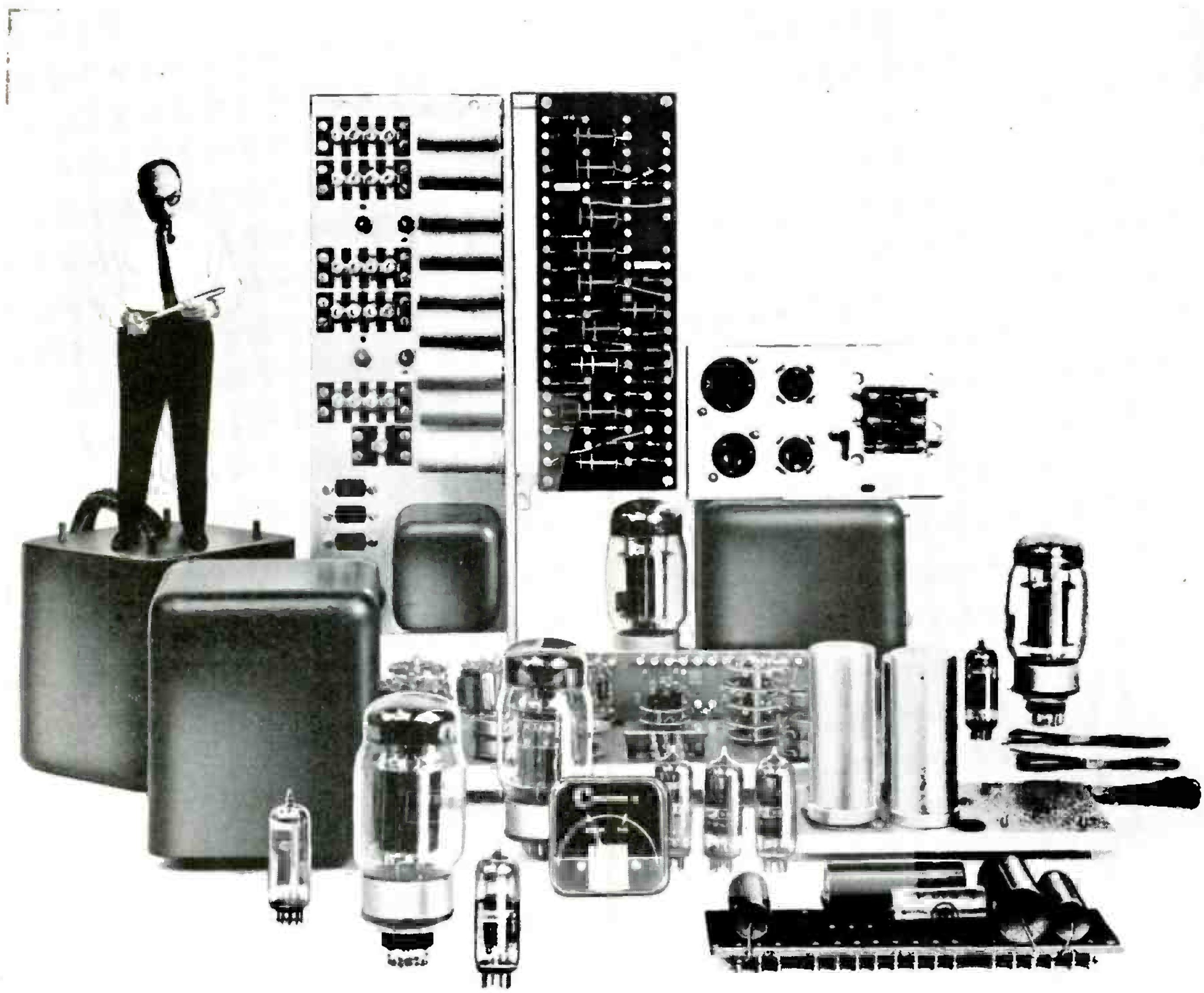

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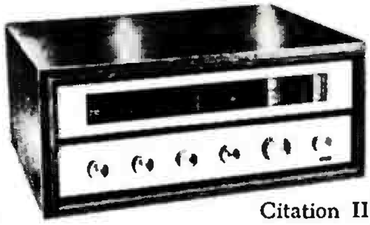

Citation III

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the position of the ionizer grid with respect to the filter should be reversed. In this case the air would pass first through the ionizer grid, then through the filter. Such an arrangement will provide improved filtering at the expense of greatly reduced ion output.

I also want to correct the statement I made relative to treating of the metal filter. Oil treating the metal filter in the normal manner improves the filtering action and it is recommended that this be done in all cases.

As a final comment, the device as described in the article was installed in January of last year and was operated at two-week intervals during the ensuing three months. Although ion-measuring equipment was not available, the comparative cleanness and freshness of the air while the unit was operating left little doubt as to its effectiveness. Cooking odors which normally persisted for hours would be dispelled in minutes with the unit in operation. The tendency to mustiness or slight gas odor when the house remained closed and unoccupied for several days was not in evidence with the unit turned on.

There are other observations that will not be enumerated because of their probable controversial nature, but suffice it to say that in our opinion, the device is well worth the reasonable cost and time required to put it together. I consider it strictly experimental and a complement to commercial room ionizers rather than a substitute for them.

R. E. PATRIE
Oreland, Pennsylvania

* * *

MULTI-PURPOSE LOW-VOLTAGE SUPPLY

To the Editors:

After a check with local supply houses, I am unable to find any source for the 1N1450 silicon rectifiers mentioned in Mr. Caringella's article (August 1961), "Multi-Purpose Low-Voltage Supply." Also, I looked up the maximum dissipation rating of the 2N554 and found it to be 10 and not 60 watts.

D. HERMAN
Louisville, Kentucky

According to the author, the 1N1450 was originally manufactured by Audio Devices, whose semiconductor division has recently become Standard Rectifier Corp. *The new* Standard Rectifier *designation for this diode is 10F1. The nearest equivalent is the* Sarkes Tarzian *10LF (JETEC 1N1089). The* International Rectifier *6F10 will also work well; however, it is a stud-mount diode.*

According to published Motorola *specifications, the type 2N554 has a collector dissipation of 45 watts at a mounting-base temperature of 25 degrees centigrade. Two of these transistors in parallel result in a total allowable dissipation of 90 watts. However, this value must be derated 1 watt for each degree centigrade rise in base temperature. The maximum allowable dissipation at a base temperature of 80 degrees is 10 watts per transistor, or a total of 20 watts for the parallel combination. With proper heat sinking, as recommended in the article, a total of 60 watts can be tolerated.—Editors.* ▲

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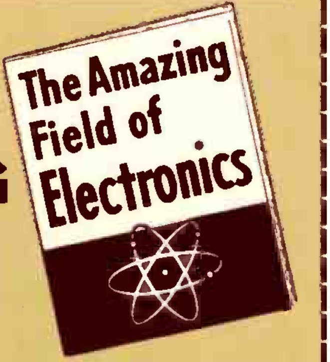

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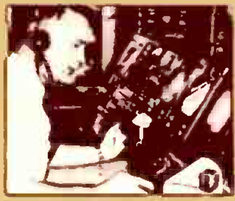

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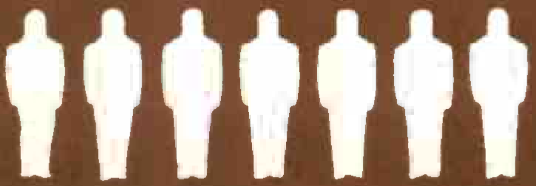

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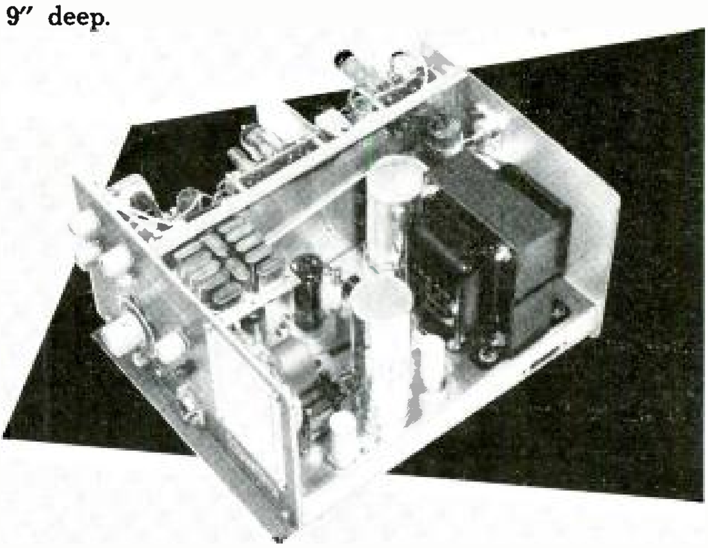

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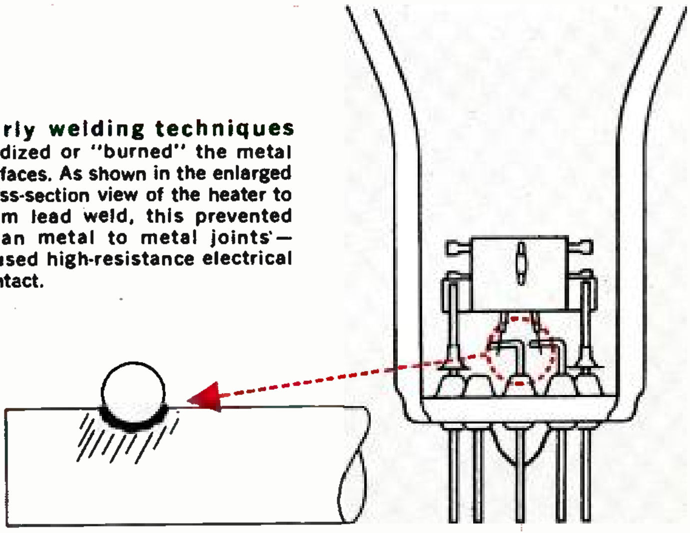

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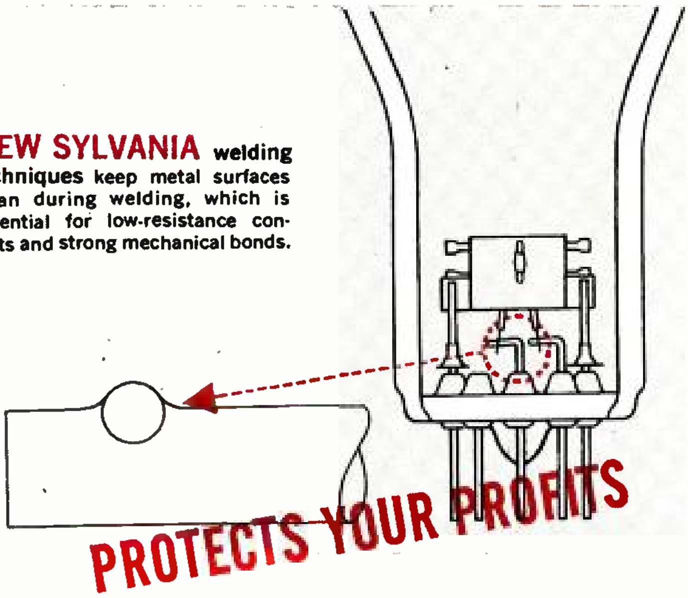

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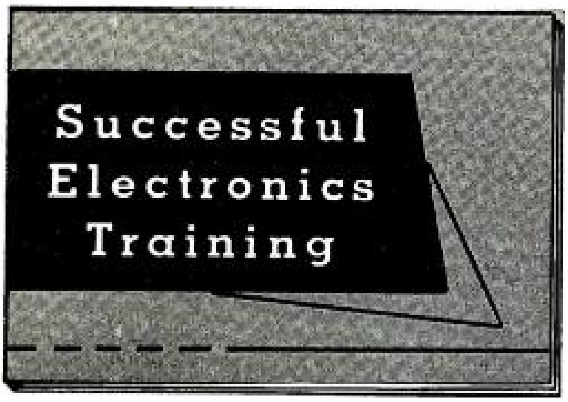

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Magnetic equalization plug-in adapters are supplied with the cartridge, for connection to RIAA equalizing preamplifiers with a 47,000-ohm input impedance. The cartridge may be connected to flat (unequalized) inputs with a nominal sensitivity of 0.2 volt and an impedance of 750,000 ohms to 1 megohm, using a simple equalizing network. In this case, it is self-equalizing for the RIAA characteristic. With the magnetic adapters, the output is rated at 10 millivolts for a stylus velocity of 5 cm./sec., with channel outputs matched at 1000 cps to within 2 db.

Physically, the *Astatic* 45D cartridge is housed in an attractive gold-finished case, which plugs into a mounting clip. The cartridge may be removed when mounting the clip in the arm and snaps into place easily when this has been done. The stylus assembly is easily removed without tools. We were struck by the minute size of the jewel, which is difficult to see with the unaided eye and is mounted at the end of a very small diameter stylus tube.

Being non-magnetic, the 45D is completely insensitive to magnetically induced hum. It is, of course, important to ground its case for electrostatic shielding, and the grounding wire is supplied with the cartridge for use with those arms which do not provide a ground for the cartridge. Another special feature of this cartridge is its built-in *alpha*-ray source which is supposed to remove the static charge from the record surface as it is being played, reducing the accumulation of dust in the grooves. During our limited use tests of this cartridge we were unable to detect any effect from this source, although it might prove useful over an extended period of time.

Two samples of this cartridge were tested. The first was a pre-production model, which did not meet the manufacturer's specifications for high-frequency response. The second unit was part of a regular production run and is covered in this report.

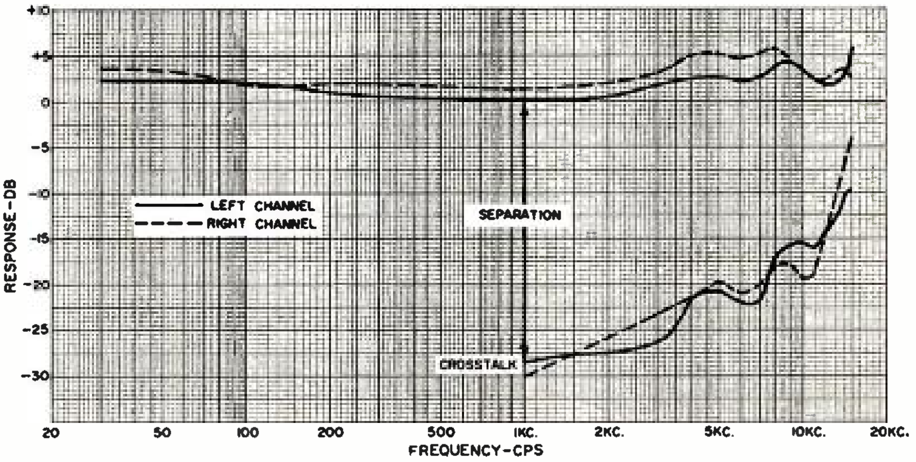
We tested the *Astatic* 45D by mounting it in an *Audio Empire* 98 arm and playing various test records. This was done with the magnetic adapters, terminated in 47,000 ohms, and with the self-equalizing connections, terminated in 1 megohm. In the latter mode of operation, each channel is shunted by a series combination of 110,000-ohm resistor and .003-μf. capacitor as well as the normal 1-megohm load.

First we determined the cartridge's tracking force requirements by playing the *Cook* Series 60 and *Fairchild* 101 records, which carry very high recorded velocities at very low and at intermediate frequencies respectively. The tracking force was adjusted to the minimum which would permit satisfactory tracking, which proved to be 3 grams. This value was used for the balance of the test. In listening tests, where these extreme velocities are rarely encountered, 2 grams proved to be entirely adequate.

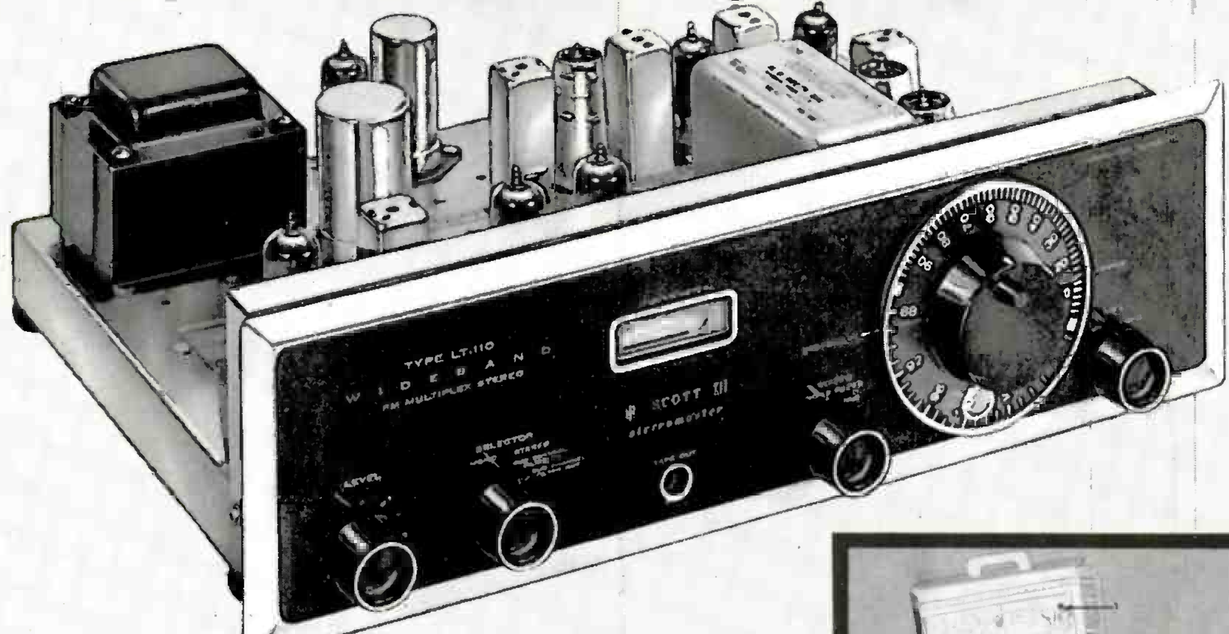
The frequency response of the *Astatic* 45D proved to be slightly better than rated, within ± 2 db from 30 to 15,000 cps, which are the limits of the *Westrex* record. The channel outputs, which average about 7 millivolts at 1 kc. and 5 cm./sec. velocity, are matched within 1.5 db at 1000 cps, although they differ by as much as 2.5 db in the 4 to 5 kc. region. The channel separation is excellent, averaging 30 db at 1 kc., 20 db at 10 kc., and 6 to 15 db at 15 kc. (depending on which channel is measured).

The monophonic *RCA* 12-5-49 test record was used to measure the self-equalization of the cartridge with the recommended termination for flat am-

(*Continued on page* 22)



SUPERB NEW SCOTT MULTIPLEX TUNER KIT

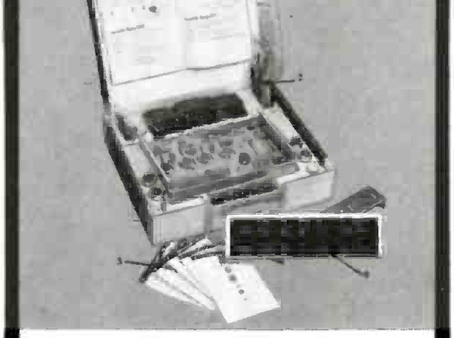


Now you can build a Multiplex Tuner that meets rigid factory standards

Now have the fun of building a genuine H. H. Scott Wide-Band FM Stereo Tuner in just a few hours . . . and save money, too. Revolutionary Scott-developed kit building techniques assure you of performance equaling Scott factory units.

The new LT-110 Scottkit features a pre-wired and tested multiplex section plus the famous silver-plated factory built and aligned front end. Sensitivity of this magnificent new tuner is 2.2 µv. IHFM. There are special provisions for flawless tape recording right "off-the-air."

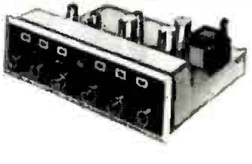
Scott Wide-Band multiplex tuners are the standard of the industry. They have been chosen by leading FM stations from Boston to San Francisco. If you want to build a truly professional component choose a Scottkit. All H. H. Scott kits are backed by over 15 years experience in the design and production of superb components. Important features include front panel tape recorder output and precision illuminated tuning meter. All critical parts heavily silver plated. Unique Ez-a-Line system assures factory performance without expensive test equipment. Dimensions: 15½ W x 5¼ H x 13 D in accessory case.



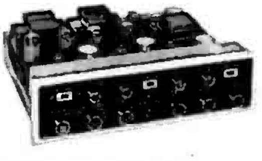
These Exclusive Scottkit Features Make Kit Building Foolproof and Fun

1. All assembly diagrams show parts in exact size and in **full color**, eliminating mistakes.
2. All wires cut to exact length and pre-stripped assuring correct lead placement and dress.
3. Exclusive Part-Charts with parts mounted in order of assembly, eliminating confusion and mistakes. **No loose bag of parts.**
4. Handsome appearance makes Scottkits completely professional in looks as well as in performance.

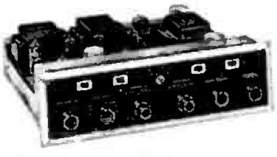
New Scott Amplifier Kits to match the LT-110



LC-21 Preamplifier Kit
Performance so outstanding this kit is used for laboratory purposes. Hum level —80 db. distortion less than 0.1%, frequency response 8 to 50,000 cps. **$99.95***
Matching LK-150 130 Watt Power Amplifier **$169.95***



LK-72 80 Watt Stereo Amplifier Kit —
Plenty of power for any hi-fi system. Complete tape recording and monitoring facilities. Oversized transformers weigh 12 pounds! Performance equal to the best pre-amp/power amp systems. **$159.95***



LK-48 48 Watt Stereo Amplifier Kit —
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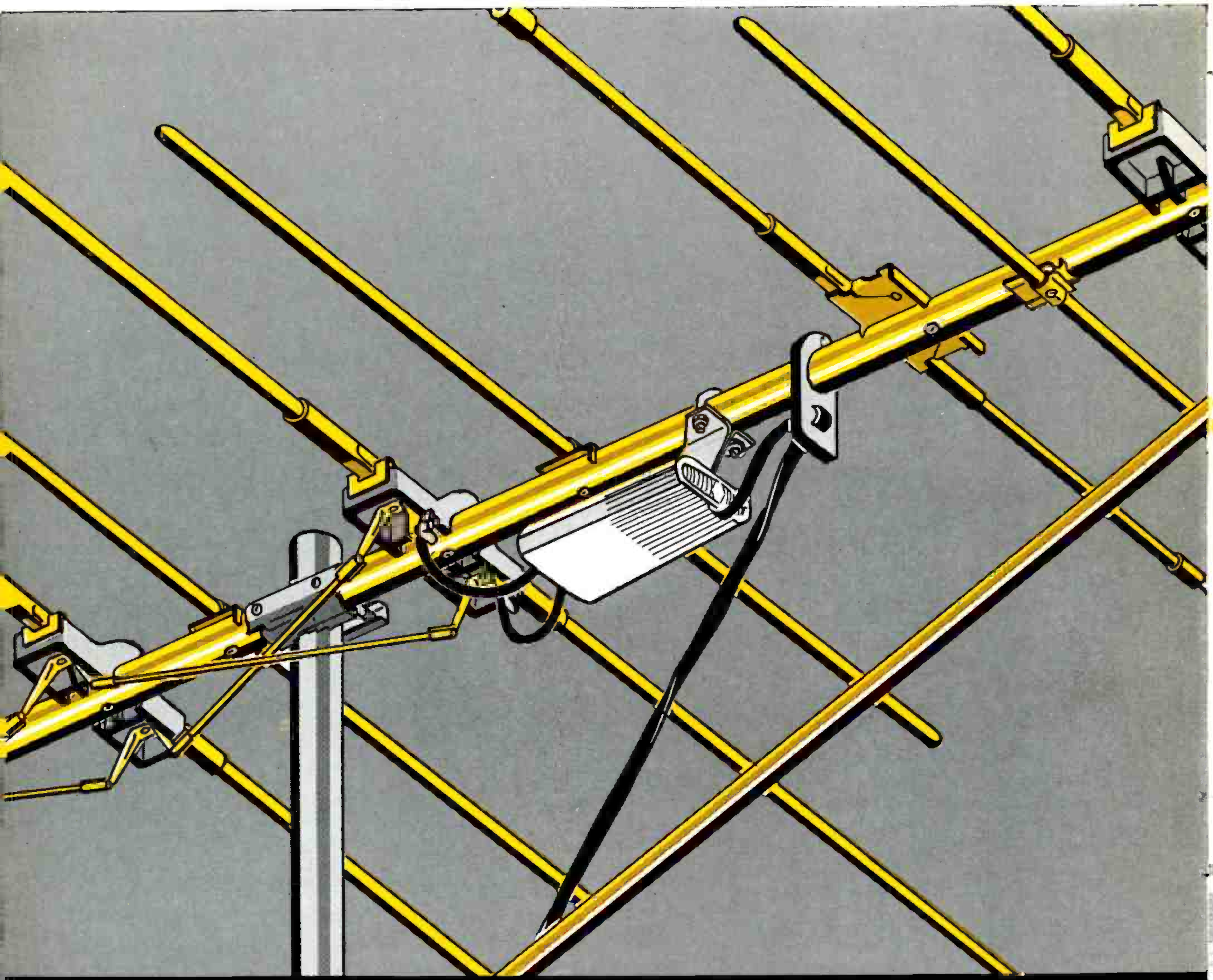

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JETRON transistorized booster-coupler model 0020

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The remarkable performance of the Crossfire is made possible by the use of a revolutionary engineering principle . . . Proportional Energy Absorption. In other antennas, a great many of the elements are "lazy" on any given channel . . . they are not actively working. But in the Crossfire, Proportional Energy Absorption puts more picture-pulling elements to work on **every** channel. The result: the highest gain and front-to-back ratios ever built into a broad band antenna!

The Crossfire's performance is coupled with "take anything" construction that provides exceptional resistance to high winds and ice loading.

Antenna-mounted booster... install it, then forget it!

The Jetron is built to last! Not only does it have fewer components than any other booster, but the Jetron amplifier pod on the antenna contains no transformer, no rectifier, no filter capacitor. These components are all in the power supply, right by the set, where servicing is quick and easy. This power supply also serves as a 4-set coupler.

The Jetron can be used with **any make or type of antenna** to add electronic power boost. You are not limited to a particular antenna. That's why the Jetron provides a convenient, trouble-free means of enhancing the performance of already existing installations.

Here's why no other booster measures up to the Jetron!

FEATURE	Jetron	Booster A	Booster B	Booster C
No. of sets that can be coupled	4	1	2	4
Newest low-noise transistor	Yes	No	No	Yes
Low-cost AC operation	Yes	Yes	Yes	No
Antenna-mounted components subject to failure (electrolytic condenser, selenium rectifier)	No	Yes	Yes	No
No. of antenna mounted components	14	26	31	22
Highest gain on:	high band	low band	low band	low band
Consumer-appeal styling	Yes	Yes	No	No

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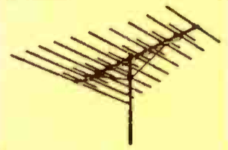
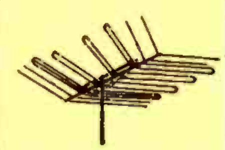
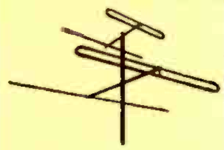
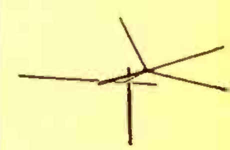
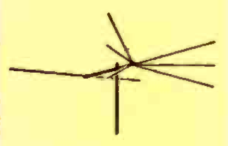
PROTECTS	antenna performance against salt air, industrial atmosphere, chimney smoke, and other corrosive agents.
CONDUCTS	electrical energy and assures metal-to-metal contact. Does not have to be scraped off like anodizing. E•P•C protects the entire antenna . . . and really lasts!


Crossfires


T-W's


Fold Flectors


Conicals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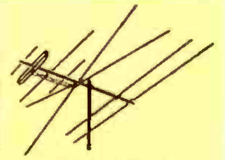
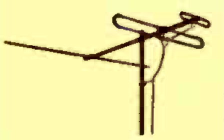
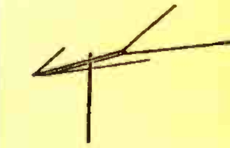
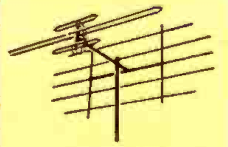
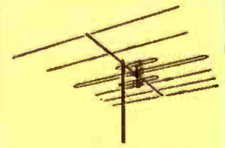
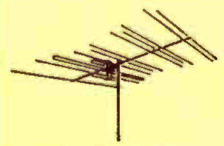

Conical Yagi

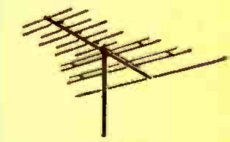

Dual Flector

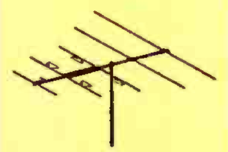

City Vee


Champion


Rainbow


Super Rainbow


Skyblazer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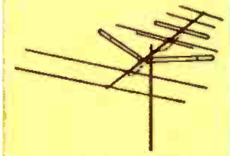
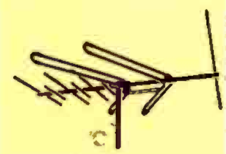
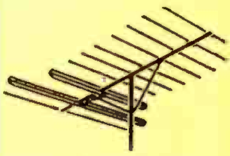
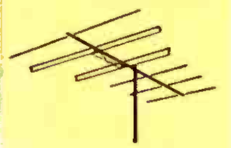
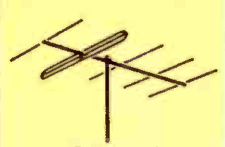
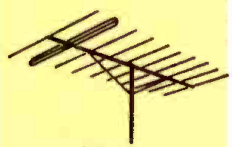

Color Prince

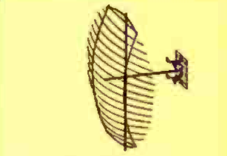

Color King

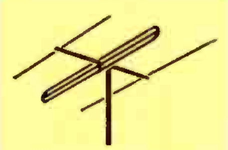

Futuramics

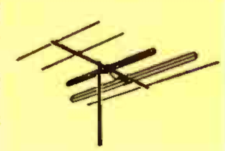

High Banders

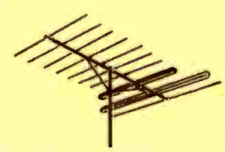

5-element Z-Match Yagis

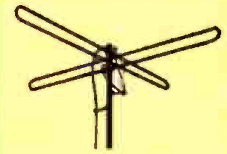

10-element Z-Match Yagis


UHF Para-Scope


3-element FM Yagi


5-element FM Yagi


10-element FM Yagi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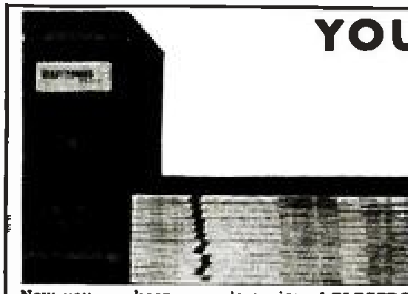

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plifiers with a 1-megohm input impedance. One channel alone was measured. The response was very flat up to about 8000 cps, showing a couple of small peaks above that frequency. Even so, it was within ±2.5 db from 30 to 15,000 cps, with an output level of 75 millivolts at 1 kc. and 5 cm./sec. velocity. If it is planned to use the cartridge in this manner, the amplifier should have high gain through its "Aux." or other high-level input. Not all amplifiers have sufficient gain to be driven adequately by this output voltage.

In listening tests, the *Astatic* 45D sounded as good as it measured, which is to say very good. Its needle talk is exceptionally low and the sound has a smooth, unstrained quality. There is nothing in its sound quality to suggest the "ceramic quality" which has been a characteristic of some ceramic cartridges. It is doubtful if anyone hearing it would think it were anything but one of the better magnetic cartridges. The use of the magnetic adapters is recommended whenever possible. The cartridge was plugged into the ceramic cartridge input of a good, moderately priced stereo amplifier, producing good sound but lacking the brilliance when compared to the magnetic input of the same amplifier.

The *Astatic* 45D cartridge sells for $26.70 net, complete with two plug-in magnetic input adapters. ▲

Harman-Kardon "Citation III" FM Tuner

For copy of manufacturer's brochure, circle No. 59 *on coupon (page* 122*).*

UNLIKE amplifiers, which have been available in kit form from several manufacturers for some time and which are capable of very fine performance, really high-quality FM tuners have been rare in the kit field. This is because of the problems of alignment by relatively unskilled kit builders, without adequate test equipment.

Harman-Kardon, whose "Citation" series of amplifiers has earned a high reputation for quality, has developed an FM tuner kit which is a perfect companion to the amplifiers. The "Citation III" tuner incorporates many advanced design features which set it apart from most other tuners—manufactured or kit-built.

The r.f. amplifier section begins with a 6CW4 nuvistor tube, in a grounded-cathode connection. A double-tuned r.f. input circuit improves image and i.f. rejection, which are rated at −70 db and −90 db respectively. The second r.f. amplifier is ½ECC85, connected as a grounded-grid stage. Another tuned circuit is in its plate, making a total of three tuned tanks in the r.f. amplifier section. The other half of the ECC85 dual-triode serves as a broadly tuned r.f. amplifier. The mixer/oscillator is an ECF80 triode-pentode. The triode oscillator section is effectively decoupled from the pentode mixer section by signal injection into the grid of the

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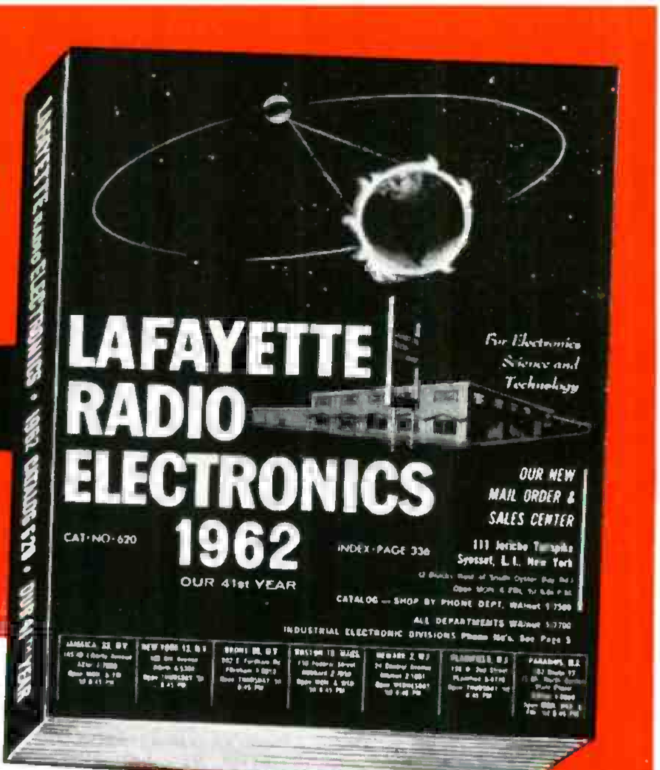

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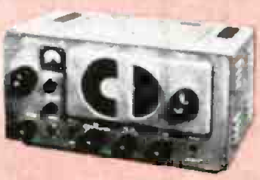

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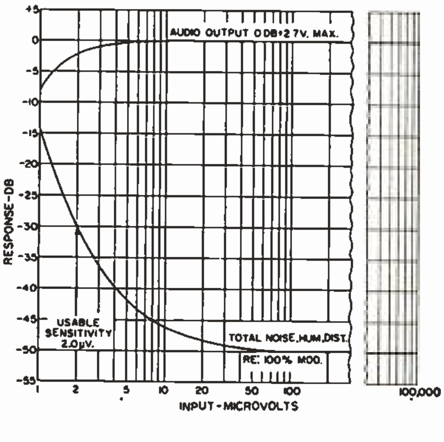
third r.f. stage rather than into the mixer grid.

Automatic frequency control is applied by means of a silicon diode used as a voltage variable capacitor. The bias voltage for the silicon diode is regulated by a neon tube to minimize drift.

There are two stages of i.f. amplification using 6AU6's, followed by two stages of gated-beam limiters (6BN6's). A signal-level meter is actuated by the grid bias of the first limiter. The interchannel muting voltage is applied to the third grids of both 6BN6 tubes. This type of muting circuit is not only free from thumps, but is especially desirable in multiplex reception since it mutes the noise ahead of the detector rather than in the audio as in some other tuners.

The discriminator, using semiconductor diodes, is isolated from the de-emphasis network by a cathode-follower, which also provides a low-impedance source for driving an external multiplex adapter. *Harman-Kardon* claims that the high, constant impedance presented to the discriminator by this circuit results in reduced distortion as compared to the usual circuit where the de-emphasis network loads the discriminator directly. The audio section is a two-stage feedback pair, similar to those employed in the "Citation" preamplifiers, and power amplifiers. It offers a useful gain, together with a very low output impedance and low distortion.

Obviously, this is no simple tuner and hardly the sort of thing which one would expect to be built successfully by a hobbyist. The secret of its success is the pre-assembly and pre-alignment of the critical circuits in an FM "tuner cartridge," which contains the second and third r.f. stages, mixer and oscillator, and two i.f. stages. This fully shielded unit also has the tuning capacitor and coils for the oscillator and second r.f. plate coil. The constructor, apart from the mechanical assembly of the balance of the tuner and the mounting of the "cartridge" in its cut-out, is required to wire the nuvistor r.f. stage and its tuning circuits, the limiters and discriminator, audio section, and power supply.



The alignment procedure is simple and foolproof, as it has to be for a successful kit tuner design. The level and balance meters are used as indicators and the interstation hiss is used as a test signal. The alignment consists of fully detuning the discriminator secondary and peaking the primary for maximum balance meter reading on noise. The limiter transformers are also peaked in the same manner. The secondary is then tuned for zero-center meter reading. Front-end peaking is carried out using received stations.

We tested the tuner, which had been constructed from a kit by someone relatively unfamiliar with kit building, after alignment in accordance with the above procedure. Then we attempted to improve its performance by alignment with a laboratory-quality FM signal generator and distortion analyzer. No significant change was observed, other than a reduction of possibly 2 or 3 db in residual distortion when it was instrument-aligned. Since this amounted to a reduction from 0.4% to 0.3% harmonic distortion, at 100% modulation, we would consider that the simplified alignment procedure is fully adequate to obtain the maximum performance from the tuner.

In practically every respect checked, the "Citation III" met or exceeded its specifications. The usable sensitivity (IHFM method) was 2 microvolts, as rated. The capture ratio was 5 db, slightly better than the rated 5.5 db. The distortion at 100% modulation was 0.3% to 0.4%, depending on the alignment method. *Harman-Kardon* claims 0.1%, which is less than the residual distortion of our signal generator. The hum level was measured at −60 db with respect to 100% modulation level. This is also roughly the capability of our

(Continued on page 102)

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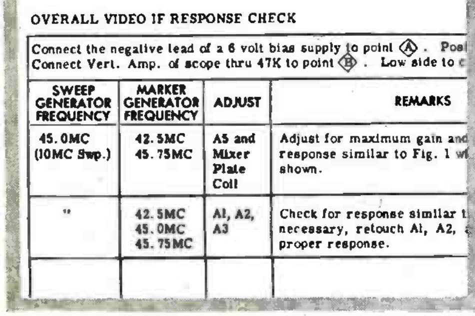


OVERALL VIDEO IF RESPONSE CHECK

Connect the negative lead of a 6 volt bias supply to point Ⓐ. Posi
Connect Vert. Amp. of scope thru 47K to point Ⓑ. Low side to c

SWEEP GENERATOR FREQUENCY	MARKER GENERATOR FREQUENCY	ADJUST	REMARKS
45.0MC (10MC Swp.)	42.5MC 45.75MC	A5 and Mixer Plate Coil	Adjust for maximum gain and response similar to Fig. 1 wi shown.
"	42.5MC 45.0MC 45.75MC	A1, A2, A3	Check for response similar t necessary, retouch A1, A2, proper response.

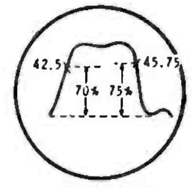


FIG. 1

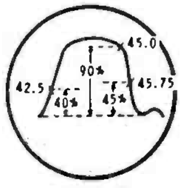
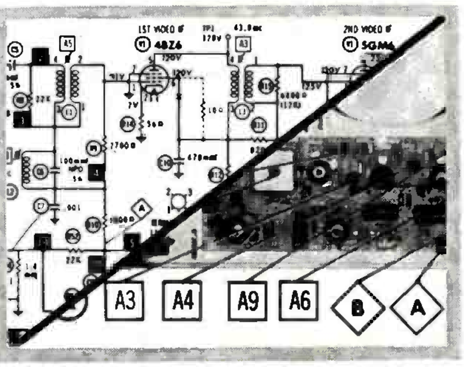


FIG. 2



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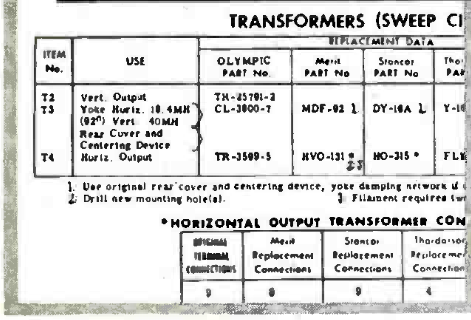


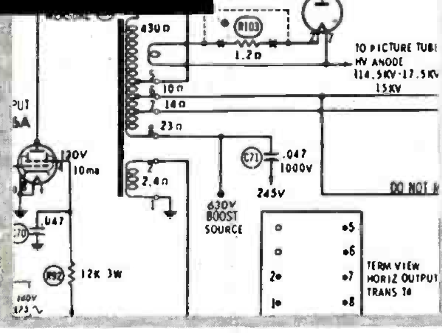
TRANSFORMERS (SWEEP CI

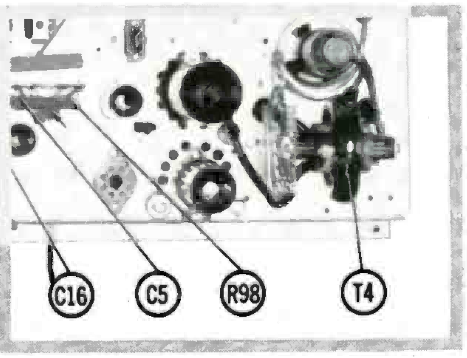
ITEM No.	USE	REPLACEMENT DATA OLYMPIC PART No.	Merit PART No	Stancor PART No	Tho PAR
T2 T3	Vert. Output Yoke Horiz. 10.4MH (92°) Vert. 40MH Rear Cover and Centering Device	TH-25701-2 CL-3000-7	MDF-92 1	DY-10A 1	Y-1
T4	Horiz. Output	TR-3509-5	HVO-131 * 2 3	HO-315 *	FLY

1. Use original rear cover and centering device, yoke damping network if
2. Drill new mounting hole(s).
3. Filament requires tw

*HORIZONTAL OUTPUT TRANSFORMER CON

Original Terminal Connections	Merit Replacement Connections	Stancor Replacement Connections	Thordarson Replacement Connection
9	8	9	4





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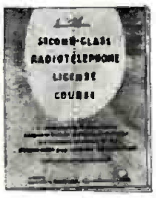

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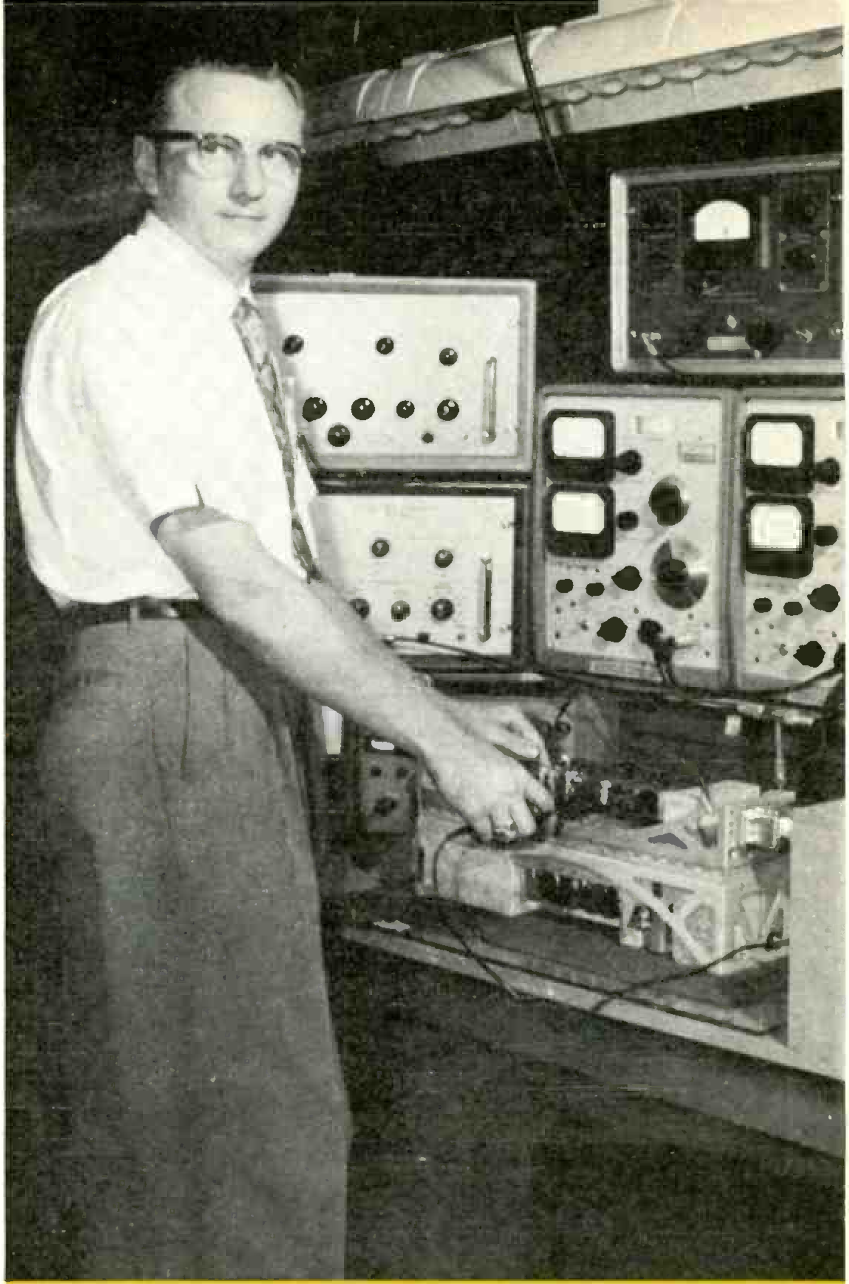

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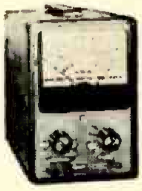

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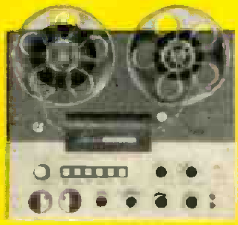

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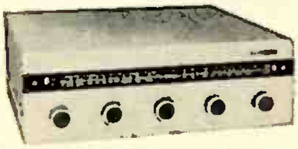

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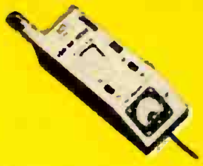

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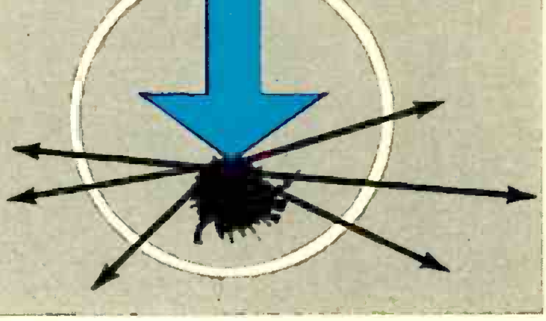
ultrasonics IN TESTING



A new and fast-growing technique of non-destructive industrial testing uses ultrasonic waves to pinpoint flaws in materials and to measure thickness.

ONE of the major fields in which ultrasonics is serving industry is in the inspection and gaging of various materials. The equipment and techniques used for these inspections are quite different from those for power applications such as cleaning and drilling, and yet they all have certain basic things in common.

All forms of ultrasonics use high-frequency mechanical vibrations, or ultrasound, which is produced by exciting a transducer (usually piezoelectric) from an oscillator circuit, causing vibrations in the transducer which, in turn, are introduced into the part under test.

For testing and gaging, the sound waves are sent into the part through a liquid couplant and propagate in a fairly well defined beam through the part, reflecting back from various boundaries within the part. These boundaries can be either geometric boundaries, such as shoulders or the flaws which might intercept the sound beam, or they could be the back side of the part. Reflection occurs when the two materials making up the boundary have different acoustic impedances, causing either partial or complete reflection of the sound energy.

There are two basic types of ultrasonic equipment, which differ primarily in their means of producing ultrasonic vibrations as well as in their presentation of information. These have been classified as ultrasonic *resonance* equipment (used primarily for thickness gaging) and ultrasonic *pulse-echo* equipment (used mostly for flaw detection). The distinction is not absolutely rigid since some flaw detection can be done with the resonance equipment, and much thickness gaging, particularly in corrosion work, is done with the pulse flaw detectors.

Pulse Flaw Detectors

The ordinary pulse-echo flaw detector is required to perform three basic functions: to *detect* internal flaws, determine their *location*, and finally provide information for the *measurement or evaluation* of the internal flaws. This is accomplished through the interaction of the components shown in Fig. 1, which is a simplified schematic showing a standard test. Here the clock acts as a trigger or synchronizing circuit, initiating several other circuits. The signal is first sent to the pulser, which in turn sends a high-voltage electrical signal of very short duration to the transducer. The transducer converts the electrical signal to mechanical or sound waves and this sound propagates into the material under test.

A portion of the electrical signal to the transducer is also carried to the receiver-amplifier which produces a vertical deflection on the face of the CRT. The clock circuit also initiates the sweep which provides a time base for determination of

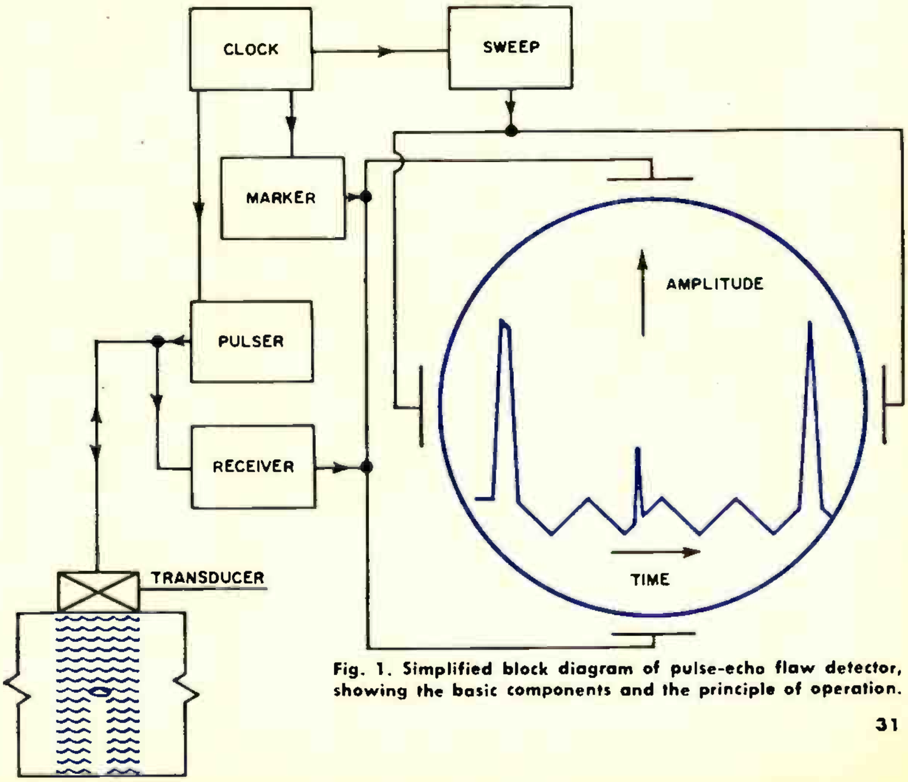


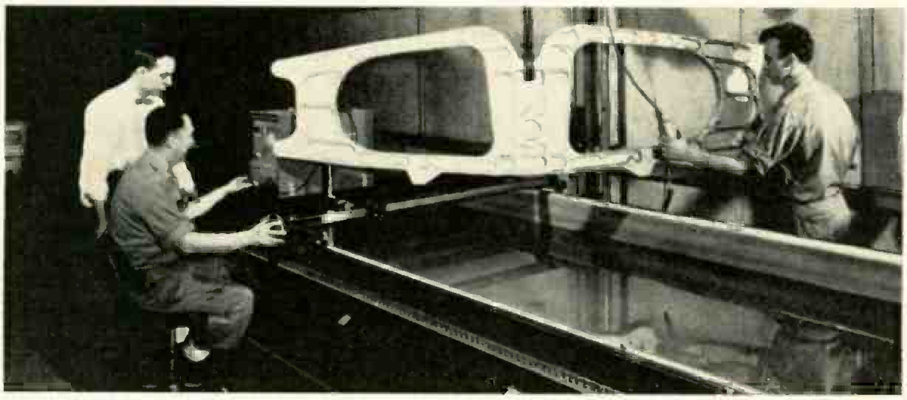
Fig. 1. Simplified block diagram of pulse-echo flaw detector, showing the basic components and the principle of operation.

Pulse-echo flaw detector being used to inspect steel plate.

the location of defects in the material.

After the initial pulse has occurred, and as time progresses, the sound propagates through the material at a constant velocity and reflects from geometric boundaries or from internal discontinuities. (It should be noted that the time, while a finite quantity, is relatively short —on the order of microseconds—due to the extremely high velocities of sound in solid materials.) The trace on the CRT moves from left to right, providing the time base for determination of distance. When sound reflects from an internal boundary, it is picked up by the transducer and converted into an electrical signal. Note that the transducers used in most flaw detection equipment provide a reversible piezoelectric effect, that is, they can act as transmitters or receivers.

The received signal is amplified and provides another vertical deflection of the CRT trace. The horizontal displacement of the CRT trace basically represents time. In most cases, however, it is more convenient to consider the distance that the sound has travelled. We assume that sound in a given material has a constant velocity and the trace of the CRT is usually calibrated in terms of distance. This can be done through an overlay on the face of the CRT, and is also done quite often with internal electronic markers. These electronic marker systems have several different appearances in different instruments and are usually adjusted to represent some convenient increment of distance, such as a foot, an inch, a centimeter, etc. The markers may appear as inverted pips on the sweep, a square wave superimposed on the sweep or a pyramid or triangular wave superimposed on the sweep. The latter is very useful when using angle techniques, as described below.



Immersion setup employed to test large forgings for internal defects. The ultrasonic indicating equipment being utilized is shown at the left in the photograph.

Seamless aluminum tubing used in Titan missile is measured with ultrasonic thickness tester. Instrument requires access from one side, provides .1% accuracy.

Accomplishment of the three basic goals—*detecting, locating* and *measuring* flaws—depends on the proper functioning of the electronic circuitry in the instrument. However, of equal importance in the successful use of the equipment is some knowledge of the test problem itself. The operator usually has some prior knowledge, either through past experience based on previous failures or through intuitive knowledge based on processing variables such as possible type, location, orientation, and extent of defects in a given material. With this knowledge, he can select a suitable technique to allow the sound waves to intercept the flaw approximately perpendicular to the direction of propagation of the sound waves, thus guaranteeing a suitable reflection of the sonic energy back to the transducer.

The sound can be introduced straight into the material, perpendicular to the entrant surface, if the flaw is thought to be generally parallel to this surface. By means of suitable wedges interposed between the transducer and the material, it is also possible to have the sound wave enter at an angle to the surface. This is done if the defect has some peculiar orientation, or if the geometry of the part prevents use of a straight beam. The sound propagates through the material much like a light wave would, bouncing between two reflecting surfaces. The two techniques are shown in Fig. 2A.

The earliest successful use of ultrasonics in flaw detection was carried out on large massive parts such as steel forgings and plates which could not be adequately tested with other methods available at that time. Many users quickly recognized the potential capabilities for the inspection of smaller, more intricate, or more critical parts, and the use of ultrasonics was expanded.

The aircraft industry has accomplished more, perhaps, than any other basic industry in the application of ultrasonics. All major structural parts of modern aircraft are ultrasonically tested for the presence of internal flaws, such as cracks, forging bursts, and porosity.

In order to permit the inspection of complex geometric parts, as well as to increase the testing speed on simpler geometrics, the use of immersion testing was developed. Immersion testing is basically a scanning technique in which both the part and the transducer are immersed in a liquid bath as shown in one of the photographs. Instead of having the transducer touch the part, the sound is transmitted through the liquid and enters the part either perpendicular or at an angle, depending on the test requirements. Among the advantages of immersion testing are its capabilities for high speed and its extreme flexibility in scanning techniques, including automatic scanning and the possibility of focusing the sound

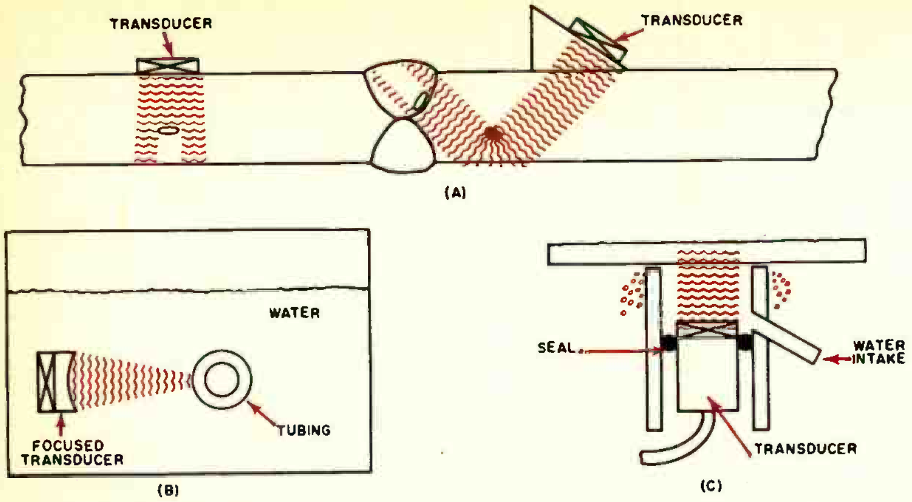


Fig. 2. (A) Two basic testing techniques—straight beam and angle-beam. Angle-beam testing is useful in detecting poorly oriented flaws. (B) Focused transducers are used in immersion testing to intensify and direct the sound beam. (C) Bubbler transducer uses continuous-flow water column for uniform sound coupling. This technique is most useful in high-temperature applications to prevent transducer damage.

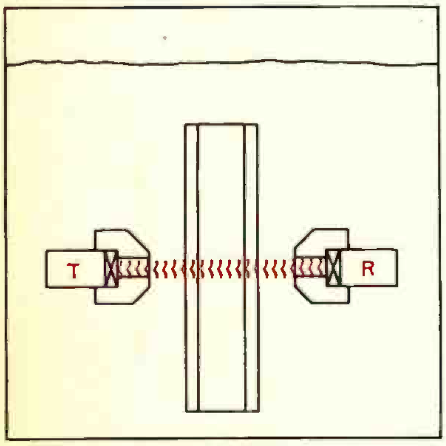


Fig. 3. Through transmission in immersion testing detects separations in laminated parts. Drop in received signal indicates the position and the size of the separation.

waves for special uses (see Fig. 2B).

Several modifications of the immersed scanning technique have been introduced recently. These include contained liquid columns in such form as simple tubes or the more sophisticated rubber tire or wheel transducer. The latter consists of a transducer rigidly mounted on the axle, surrounded by a type of rubber tire filled with a suitable liquid. In production testing, the rubber tire rotates, eliminating any sliding friction or wear between the transducer assembly and the part, thus protecting the transducer. The contained column eliminates the need for large tanks which were required for complete immersion of the test piece.

Another popular design is the bubbler, or semi-contained water column, shown in Fig. 2C. Several configurations are available, including one which permits adjustment of the transducer angle to change sound angle and another designed for high temperature. In the latter, a continuously flowing water column provides both a mechanical coupling for the sound waves and a temperature differential between the transducer and the part. This permits the inspection of refinery or chemical plant process equipment while in use. Many of the vessels and pipe lines inspected in this manner operate in the range of 1000°–1200° F., and bubbler systems have been successfully used for on-stream inspection at these very high temperatures. An entirely new area of inspection has thus been opened in which periodic inspections without shutdown are possible.

Another area in which ultrasonics has been extremely valuable is the detection of lack of bond between components in laminated structures. Such diverse components as nuclear fuel plates, honeycomb aircraft wing panels, and laminated circuit boards for electronic use have been inspected utilizing both pulse-echo and pulse-through transmission techniques. In the latter a delamination, or lack of bond, casts an acoustic shadow, intercepting a portion of the sound beam which would normally pass from the transmitting transducer through the part to a receiving transducer (see Fig. 3). This approach is used when the materials or the components are too thin to provide adequate resolution of the signals using echo techniques.

Many users have found that automatic inspection systems can be economically incorporated into their production. These systems consists of a basic ultrasonic flaw detector or gage, a means of mechanically moving the transducer at a constant speed and with uniform coupling, and the use of electronic monitoring devices on the ultrasonic unit. The monitor may be used to initiate alarms, to provide marking of defective parts, or to produce permanent records of the internal condition of the part being tested. The monitor consists of a time gate, permitting the equipment to observe possible echoes from defects in a pre-selected critical area within the part, and also discriminator circuits to provide "on-off" or "go/no-go" use of the test information. Some monitors also provide a voltage output proportional to the amplitude of the defect signal which can be used for proportional amplitude recording systems.

Resonance Testing

The other major category of ultrasonic

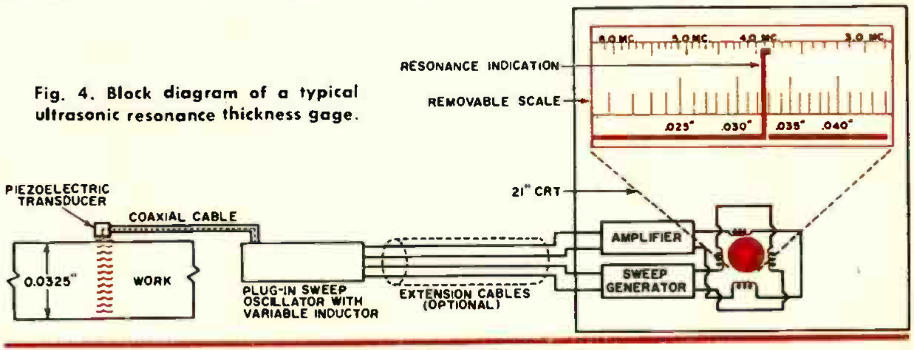


Fig. 4. Block diagram of a typical ultrasonic resonance thickness gage.

COVER STORY

THICKNESS GAGING of large, complex rocket and missile components by means of the ultrasonic resonance method has become a simple and routine procedure at Avco Corp.'s Lycoming Div. in Stratford, Conn. Because of their size and shape, the missile parts cannot be gaged to blueprint thickness requirements by more conventional methods. Using a Vidigage Thickness Tester, made by Branson Instruments, Inc., of Stamford, Conn., wall thickness is measured quickly and accurately from one side.

Among the parts gaged in this manner are Nike-Hercules nose cones (one of which is shown being checked on our cover), Minuteman re-entry vehicle structures, first and second stage Minuteman rocket-engine cases, center sections for Bullpup missiles, helicopter rotor pylons, and cannister bulkheads for the Saturn rocket engine.

The ultrasonic tester shown is employed for monitoring machining cuts as well as for final inspection. Accuracy of this testing is within .0005" limits. With this technique, an ultrasonic transducer applied to one surface of the material under test transmits energy into the material continuously. Thickness resonance in the material is indicated directly on the cathode-ray tube in the tester, as described in the accompanying article. The thickness of the part is read directly by means of an overlay scale. Interchangeable scales are provided to suit the thickness range and the type of material being tested.

Because of its speed and accuracy, this versatile electronic tool is playing an important role in this and many other industrial manufacturing plants.

(Cover photograph: Courtesy of Lycoming Div., Avco Corp.)

Contract inspection of metal parts by means of ultrasonic tester shown at right.

New transistorized ultrasonic rail flaw detector operates on batteries, weighs only 5 pounds. Change in audible tone in operator's headset signals presence of flaw in the rail.

test equipment is resonance gaging equipment. This type depends on the production of a mechanical resonance or acoustic standing wave in the part under test as the sound waves pass through.

At some specific frequency of vibration, dependent on the sound velocity in the material, a condition occurs in which twice the thickness of the material is equal to one wavelength of the acoustic wave in the material ($2T = \lambda$). This is called the fundamental resonance condition. A wavelength is equal to the velocity of wave propagation divided by the frequency [$\lambda = (V/F)$]. Combining these two equations, we find that the thickness equals the velocity divided by twice the frequency [$T = (V/2F)$]. Since all materials have some characteristic velocity which is assumed for convenience to be relatively constant, it is possible to determine the thickness of the material by finding the frequency at which the resonance takes place.

It was recognized that if only the fundamental frequencies were used, a very wide range of frequencies would be required to cover some reasonable range of thickness. For instance, in aluminum, to cover a range from .010 inch to 1.0 inch requires a frequency range from .24 megacycle to 24 megacycles. Practical limitations, primarily due to transducer design and electronic circuitry, obviated the use of only the fundamental frequency. Harmonic resonances are therefore frequently used, resulting in greater accuracy and simpler circuitry. In using harmonics, it is necessary to detect any two adjacent harmonics which produce the acoustic resonances in the part. The difference between the two harmonics equals the fundamental frequency which can be used to satisfy the above equations.

A typical ultrasonic resonance gage works as follows (see Fig. 4): An oscillator circuit is provided which is frequency modulated so that the frequency of the oscillator varies between certain limits. The oscillator output is connected to a piezoelectric transducer, exciting the transducer, and introducing sound waves into the part which the transducer contacts. When a mechanical resonance occurs in the part under test, a sudden increase in the amount of energy delivered to the transducer is produced and this is detected as a change in the plate current of the oscillator circuit.

One of the earliest practical resonant ultrasonic instruments required a manual tuning of frequency through a portion of the frequency spectrum, the detection of two or more harmonics by the operator as a change in a tone in the earphones, and then a calculation to determine the thickness of the part under test. Later developments used automatic frequency modulation and the presentation of information on a cathode-ray tube with pre-calibrated overlay scales as shown on the cover. This permitted the instantaneous determination of thickness and led to the capabilities for continuous thickness monitoring and recording, rather than mere spot checking.

With both types of resonance instruments, it is possible to obtain micrometer accuracy, usually a small fraction of one per-cent of a nominal thickness of the part, and measurements are made from only one side of a part. Electronic monitors are available to permit the initiation of alarms, marking devices, and also for the production of permanent records of thickness variation. Resonance gages have been built into automatic systems in much the same manner as the pulse flaw detectors previously described.

One of the most recent developments in resonance gaging has been the introduction of immersion testing techniques with their associated flexibility, high speed scanning, and reliability resulting from uniform sonic coupling between the transducer and the test part. When a liquid column is placed between the transducer and the part in resonance gaging, the usual result is the presence of harmonic resonances indicating the thickness of the liquid column. However, when the liquid column is terminated by a material such as a pipe wall or a sheet of material, the terminal tends to absorb energy out of the water column at the same frequency at which it would produce mechanical resonances in a contact test. Thus on the face of the CRT of the test instrument, an absence of test resonances would appear at a particular frequency; slight additional circuitry permitted the conversion of this void into a positive indication which has provided extremely reliable thickness indication.

Future Developments

What does the future hold for ultrasonic resonance gaging and pulse flaw detection equipment? One trend appears to be increased sophistication of the data-processing equipment used with the basic thickness gages and flaw detectors. This includes more elaborate recording systems, feedback devices for the control of process equipment, as well as incorporation of computer techniques.

One noticeable trend in the instrumentation itself is towards miniaturization. This includes the incorporation of transistors and other solid-state devices to produce smaller, more portable units for field testing and to provide more reliable operation for both in-plant and field use.

Another capability sure to increase in the future is the determination of more subtle differences in materials. Rather than looking for gross changes either in size or presence of flaws, such things as determination of material elastic properties through the measurement of acoustic velocity and the determination of slight changes in the lattice structure at the molecular level through variation in the attenuation or loss in sound propagating through the material, will be increased, and these laboratory techniques will some day become part of the standard production test. ▲

COAXIAL-LINE IMPEDANCE NOMOGRAM

By **JIM KYLE**

Chart for industrial technicians, experimenters, and hams who must determine coax dimensions for various characteristic impedances.

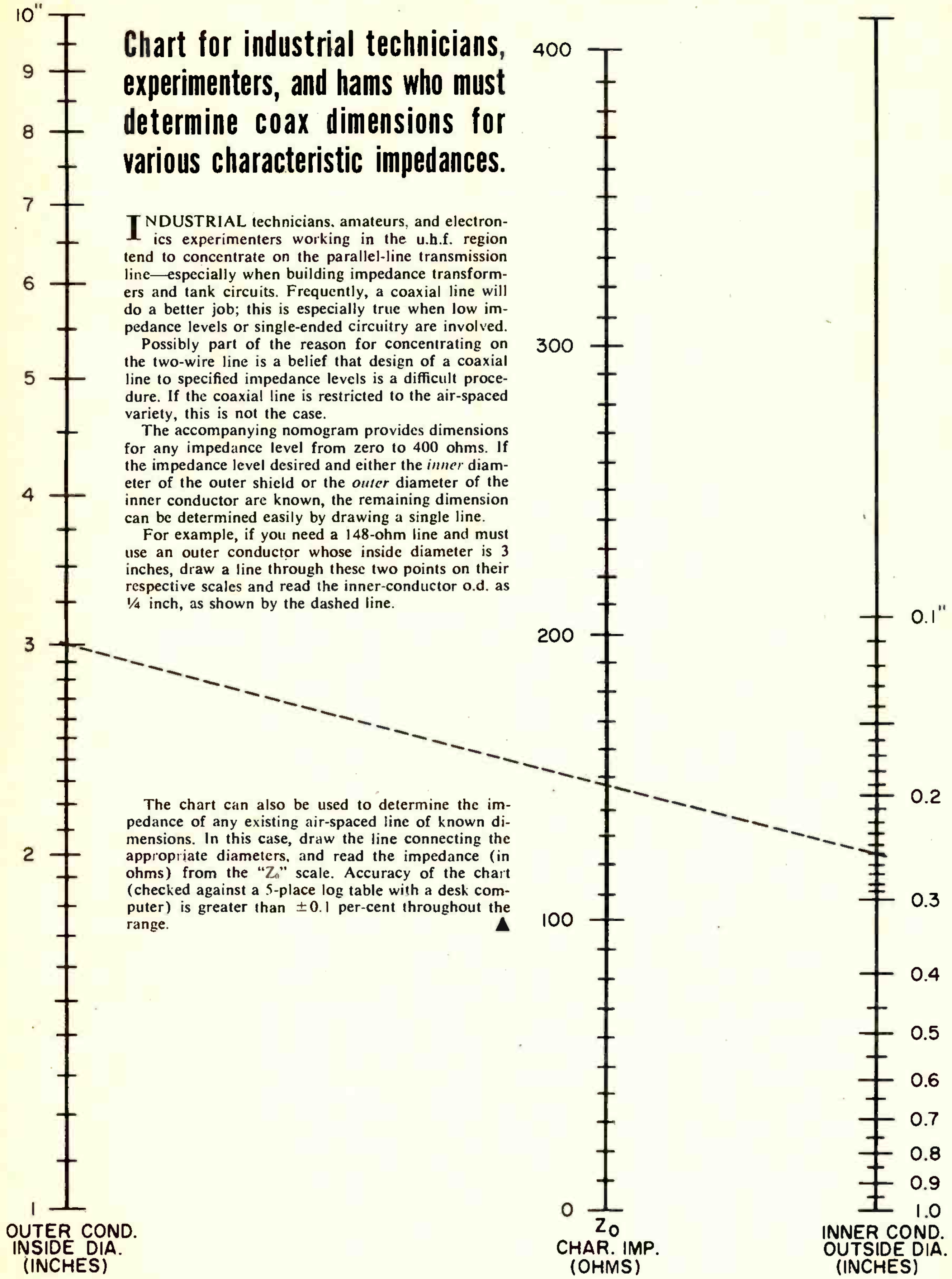
INDUSTRIAL technicians, amateurs, and electronics experimenters working in the u.h.f. region tend to concentrate on the parallel-line transmission line—especially when building impedance transformers and tank circuits. Frequently, a coaxial line will do a better job; this is especially true when low impedance levels or single-ended circuitry are involved.

Possibly part of the reason for concentrating on the two-wire line is a belief that design of a coaxial line to specified impedance levels is a difficult procedure. If the coaxial line is restricted to the air-spaced variety, this is not the case.

The accompanying nomogram provides dimensions for any impedance level from zero to 400 ohms. If the impedance level desired and either the *inner* diameter of the outer shield or the *outer* diameter of the inner conductor are known, the remaining dimension can be determined easily by drawing a single line.

For example, if you need a 148-ohm line and must use an outer conductor whose inside diameter is 3 inches, draw a line through these two points on their respective scales and read the inner-conductor o.d. as ¼ inch, as shown by the dashed line.

The chart can also be used to determine the impedance of any existing air-spaced line of known dimensions. In this case, draw the line connecting the appropriate diameters, and read the impedance (in ohms) from the "Z_0" scale. Accuracy of the chart (checked against a 5-place log table with a desk computer) is greater than ±0.1 per-cent throughout the range. ▲



DON'T OVERLOAD CAPACITORS

Choosing the right voltage rating can be tricky: the capacitor's maximum load isn't always obvious.

By MORTON H. BURKE

NO ONE wants his equipment to break down; so no one intentionally overloads his equipment or puts components in it that will be overloaded. However, in our haste to repair an old circuit or build a new one up, many of us will use the first convenient component on hand that looks as though it could do the job. Capacitors, like some other components, rebel at being employed so thoughtlessly. When abused, for example, one is likely to develop a short between its plates—and then proceed to destroy other components in its path that cannot withstand the resulting rush of current.

Excessive heat can sometimes be the direct cause of capacitor failure but, in most cases, the cause is simply the fact that too much voltage has been placed across the component. To complicate matters, the voltage rating the capacitor should have in any particular application is not always obvious.

A manufacturer specifies the maximum voltage his capacitor can withstand by printing or otherwise indicating this value right on the body of the component. But that is as far as he can go. It is up to the user to determine the rating he will need for every capacitor he puts into a circuit. His own intelligent selection will be the key factor in determining reliability and service life.

Before we go into details of determining ratings, let us look at the construction of a simple capacitor. Fig. 1 shows a typical, parallel-plate unit, which is the basis for all types. P_1 and P_2 are the two plates, which are made of conductive materials, and D is the insulating dielectric between them, which may be paper, mica, ordinary air, or some other substance. When a d.c. voltage is applied across the plates, there is a sudden, high value of current that tapers off very nearly to zero as the capacitor charges up. Thus dielectric D must soon stand up to the full amount of voltage applied.

The type of dielectric and its thickness determine how much voltage the component can actually stand before it breaks down. If too much is applied, the dielectric breakdown results in a low-resistance path between the plates, which soon becomes a dead short. Thus, instead of a capacitor, you have a resistor of very low value.

How can such an occurrence be prevented? The first and simplest rule to remember is that the d.c. working voltage at which a capacitor is rated is not the so-called average d.c. it can withstand. This leads to such arbitrary conclusions as the belief that the d.c. voltage applied to the component in normal circuit use is the key to determining the rating. The peak value to which the capacitor will be subjected at any time is a better guide. Take the ripple d.c. voltage applied across a filter capacitor, for example, from the output of a typical, full-wave rectifier, as shown in Fig. 2.

An ordinary d.c. voltmeter would read the average voltage, E_{dc}. However superimposed ripple periodically causes voltage to rise to E_p. The capacitor must be able to withstand this peak value. In any application where a.c. is superimposed on d.c., the capacitor should be rated to handle the sum of the highest d.c. level plus the peak a.c. level. And, just to be sure, add a safety factor of 20 per-cent.

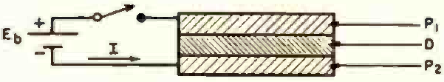


Fig. 1. Basis for all capacitors: two parallel plates separated by a dielectric.

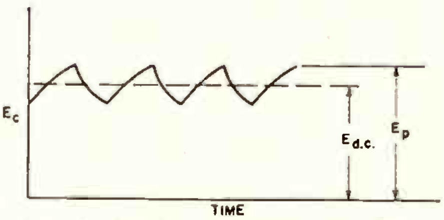


Fig. 2. Rectifier output across a filter capacitor, with a.c. superimposed on d.c.

Fig. 3. This common, 2-stage amplifier shows several conditions of capacitor use that impose different rating requirements.

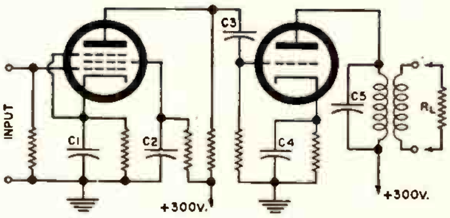


Fig. 3 shows a typical resistance-capacitance coupled amplifier stage feeding a triode which, in turn, has an output transformer delivering power to a load. The voltage ratings of the various capacitors can be determined by observing their use in the circuit. C_1 and C_4 are cathode bypass capacitors, and their d.c. rating need only be equal to the d.c. voltage between cathode and ground of their respective tubes. Since this bias voltage can be determined by simple measurement, paper, mica, or ceramic capacitors rated for at least the voltage read on the meter (plus a 20 per-cent safety factor) would easily do the job.

However, where audio frequencies are involved, C_1 and C_4 may have to be of high capacitance, and thus electrolytic capacitors may be employed. Here again, to determine the voltage rating of these capacitors, all one has to do is to measure the voltage between cathode and ground, and choose an electrolytic capacitor with a voltage rating about 10 per-cent higher than the measured amount.

Why 10 per-cent? Electrolytics are peculiar in that they must be used near their rated voltage in order for them to exhibit their rated capacitance. It's strange but true that a 10-μf., 100-volt electrolytic used in an application where only 10 volts is applied across it will not possess 10 μf. of capacitance. This is so because thickness of the dielectric oxide between the plates increases due to improper film formation. For this reason, large voltage derating of wet or dry electrolytic units is not recommended.

The voltage rating of screen bypass capacitor C_2 (Fig. 3) should also be chosen by measuring the screen-to-ground voltage with a d.c. meter and applying the 20 per-cent safety factor.

Because coupling capacitor C_3 (Fig. 3) is subjected to another set of voltage conditions, its voltage rating must be at least equal to the plate *supply* voltage. For in this case, first-stage plate voltage varies with amplitude of the a.c. voltage on the grid of the tube. In the extreme case where the plate current swings are high, this capacitor may be subjected to almost the full supply voltage. In the example of Fig. 3, coupling capacitor C_3 should be rated for at least 300 volts.

When a capacitor is used across an inductance, two factors must be considered in determining its voltage rating. Is the capacitor expected only to bypass high frequencies or is it used to resonate with the inductance? In audio circuits, where capacitors are used to bypass higher frequencies "around" the transformer primary, the voltage across the transformer primary (Fig. 3) can be no greater than the plate supply voltage. So, assuming no transients are possible, C_3 can be rated for 300 volts.

However, when capacitors are used to resonate with a coil or a transformer winding, they may be subjected to unusually high voltages. In this condition of resonance, the voltage across the capacitor depends on the current through the coil and the *"Q"* of the combination. The higher the *"Q"* and the greater the current through the coil, the higher the voltage that will appear across the capacitor. Therefore, in situations where resonance is involved, give yourself a good, husky, safety factor of 3. That is, use a 900-volt capacitor when it is resonating with a coil that is connected to a 300-volt d.c. supply. This resonance condition is the reason that the so-called buffer capacitors that are placed across the secondary windings of vibrator-type auto radios are rated for 1600 volts when the a.c. voltage across the transformer is only in the order of 600 volts.

The plate modulated circuit of Fig. 4 is a common application where the rating of a capacitor must be chosen carefully. Capacitor C_1 serves as an r.f. bypass essentially to maintain all the modulated r.f. voltage across the tank circuit of T_1. Under conditions where 100 per-cent modulation is employed, an audio voltage almost equal to supply voltage E_{bb} will appear across the secondary of transformer T_2. Fig. 5 shows the equivalent circuit when the audio voltage across the secondary of T_2 is in such phase that it adds to the d.c. plate supply voltage. Under these conditions, capacitor C_1 must withstand twice the supply voltage, E_{bb}. And because the inductance of the modulation transformer is high, transient conditions might subject capacitor C_1 to even higher voltages. If possible, where a capacitor is used in similar circumstances, choose one with a voltage rating of four or five times the plate supply voltage. Thus, with the plate supply of 500 volts shown in Fig. 4, C_1 should be rated for 2500 volts.

Power Supply Electrolytics

The type of circuit in which capacitor failure can generally do the most damage is the power supply. A glance at the full-wave circuit in Fig. 6 shows why. If capacitor C_2 were to "short out," the following events would occur at once: Excessive current through filter choke L_1 would probably cause that component to start overheating; this current would also be passing through the rectifier tubes, and would probably be beyond their maximum rating; the transformer, which is supplying this excess current, would also be overloaded.

It is possible that failure of just one of the components might open the path and forestall damage to others. On the other hand, more than one, and possibly all of these, could need replacement. For example, if rectifier damage takes the form of plate-to-cathode shorting, raw a.c. at high current would be applied to the choke from an overloaded transformer. All this could take place because the capacitor's rating was inadequate. Of course, all of this damage could be prevented with proper fusing —as in the transformer primary—but so much gear is constructed without full protection that the illustration is applicable.

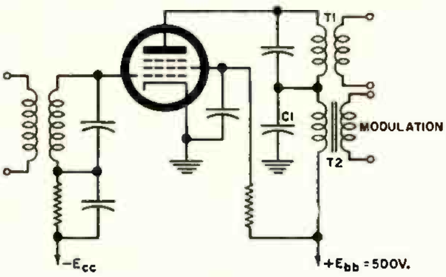


Fig. 4. A plate modulated circuit: the maximum load across C_1 is not obvious.

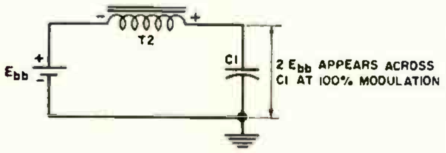


Fig. 5. Modulation voltage in T_2 secondary is in series with supply voltage.

Fig. 7 is the simple, conventional half-wave rectifier. Actual voltage at the output depends on the equivalent value of the load, represented as resistor R_L. However the peak voltage that can appear across the capacitor is 1.414 times the r.m.s. output voltage of the transformer's secondary winding. This figure, of course, is the ratio between the peak and r.m.s. values of a sine wave. Remember that capacitors try to charge up to the peak value of a voltage that is impressed across them.

Disregarding the drop across the rectifier, then, capacitor C_1 may be subjected to 354 volts (250 × 1.414). With the recommended safety factor of 10 per-cent, a 400-volt rating would be chosen.

Although the full-wave bridge of Fig. 8 is a somewhat different rectifier configuration from that just discussed, capacitor C_1 in this circuit is in a similar relationship to circuit conditions. Like its counterpart in Fig. 7, it may be subjected to the peak value of the 250-volt output from the transformer secondary. Once more, this is 354 volts and the rating chosen should be 400 volts.

Let us return to Fig. 6, where we have not considered ratings as yet. Here the highest voltage to which the filter components can be subjected is the peak value of a.c. from either side of the transformer alone, since only one of the rectifiers is active at any given instant. Since r.m.s. voltage between the center tap and either side of the secondary is 125 volts, or 177 volts peak value, a 200-volt rating is proper, rather than a 150-volt rating. This would apply both to C_1 and C_2 in Fig. 6 because, when there is no load on the supply, peak voltage will be essentially applied to both filters.

Capacitors in Series

In some power supply applications, large capacitances are required at high voltage ratings. Electrolytic capacitors afford high capacitance economically, but the required voltage rating is often not available. In order to obtain a higher voltage rating, it is permissible to connect electrolytic capacitors in series. However, to insure that the voltage divides equally across each capacitor,

(*Continued on page* 106)

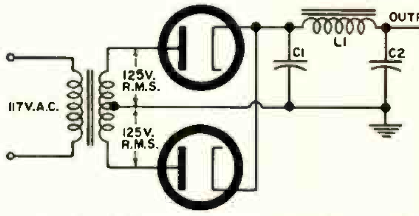


Fig. 6. Full-wave power supply. If C_2 shorts, it may damage 4 other components.

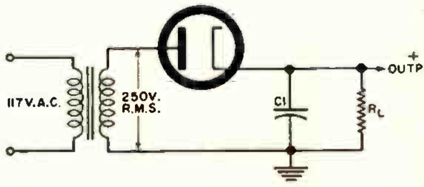


Fig. 7. Simple, half-wave rectifier. C_1 rating depends on peak transformer output.

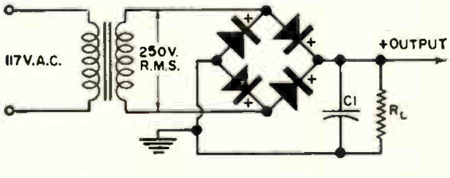
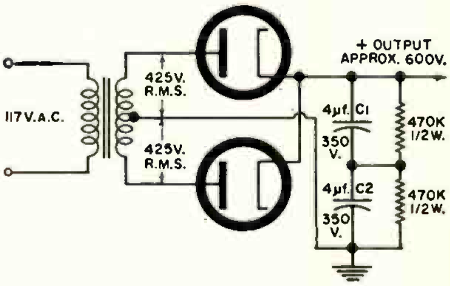
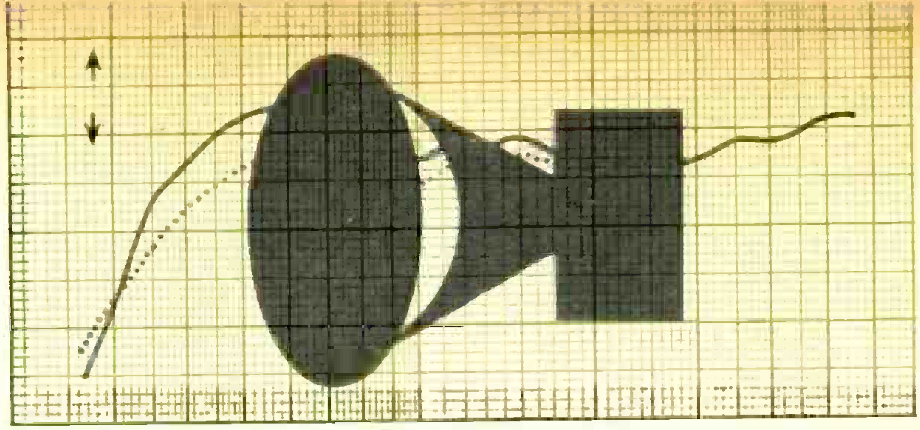


Fig. 8. Full-wave bridge: filter rating again hinges on a.c. peak to rectifiers.

Fig. 9. Filters in series to handle high voltages. Note the equalizing resistors.





The Importance of Speaker Efficiency

By *GEORGE L. AUGSPURGER*

The case in favor of the high-efficiency hi-fi loudspeaker system is presented here by one of its proponents. How does this system compare with its low-efficiency rival?

SOME audiophiles insist that all low-efficiency loudspeaker systems sound "flat" and "mushy." Others believe that all high-efficiency systems sound "harsh" and "piercing." While it is wasted time to try to change some people's opinions, most of us would like to know what effect efficiency *does* have on the performance of a loudspeaker system.

One misconception can be cleared up immediately—there is no particular characteristic sound *necessarily* associated with either high-efficiency or low-efficiency loudspeakers. You can find a loudspeaker to suit your personal taste from either group. If this is true, you may say, why should anyone buy a low-efficiency loudspeaker. The answer is simply that a good low-efficiency system can be made much smaller physically than its high-efficiency counterpart.

Loudspeaker Efficiency

To understand this a little better, let's first of all establish what we mean by loudspeaker efficiency. This can be boiled down to simple terms: efficiency is nothing more nor less than the ratio of power in to power out. If we must pump 20 watts of electric power into a loudspeaker to get 1 watt of acoustic power out, it is obviously 5% efficient.

It isn't really quite so simple because the frequency response and distribution pattern of a loudspeaker both affect its apparent over-all efficiency. Moreover, an audio amplifier tends to feed constant voltage (rather than constant power) to a speaker load. For general purposes, however, we can talk about efficiency comparisons between loudspeaker systems as long as we understand that these are based on what we hear rather than measurements.

The general order of loudspeaker efficiency is about 1 to 10 per-cent. High-quality horn-loaded systems may run as high as 25 or 30 per-cent. Remember that if one loudspeaker has half the efficiency of another, it requires twice as much electrical power to produce the same sound intensity. When this means the difference between buying a 30- or a 60-watt amplifier, it becomes something to think about.

Bass Performance

The loudest arguments about low- *vs* high-efficiency loudspeakers center about which woofer delivers the solidest whump. So, to keep from getting tangled in excessive complications, let's talk about low-frequency units only.

Rather than start with theoretical design considerations (which are available in standard texts), let's take a look at what happens in practice.

Fig. 1 shows the free-field response of two 15-inch loudspeakers, each mounted on an infinite baffle. The speakers have the same resonant frequency and are driven by the same voltage. Speaker *A* is a high-quality, very efficient loudspeaker designed for horn or reflex loading. *B* is designed specifically for use on infinite baffles or in large sealed enclosures. (The curves of Fig. 1A and B were run using analogue circuits of representative loudspeakers. For further information on this subject, refer to the article "Application of Electric Circuit Analogies to Loudspeaker Design Problems" by B. N. Locanthi in the *Proceedings of the IRE-PGA,* March, 1952.)

The output of *B* at 40 cps is only 5 db less than at 400 cps—its bass response is smooth and extended. Speaker *A,* on the other hand, is down 13 db at 40 cycles compared to its output at 400 cps. If uniform bass response in a large sealed box is the only criterion, *B* is obviously the better unit.

Yet, speaker *B* does not have *more* bass than *A*. Rather, its efficiency above 40 cps is held down in proportion. And since linear bass response is achieved at the expense of 10 db through the rest of its range, *B* requires ten times as much electrical power to deliver the same average loudness!

The preceding example gives no clue to the various factors which affect efficiency. Do not be misled into thinking that just because a particular loudspeaker is inefficient, its bass response must be smooth. It is quite easy to lose on both counts. Conversely, a high-efficiency system can be made to exhibit excellent low-frequency characteristics. This seems to be a contradiction of what is shown by Fig. 1, but these two loudspeakers, remember, are mounted on an infinite baffle.

A single loudspeaker mounted on an infinite baffle (or in a sealed enclosure) is always comparatively inefficient in the bass range. The reason is that the cone is not big enough to move much air at low frequencies. It is almost like trying to paddle a canoe with an iced-tea spoon.

Bringing Up the Bass

Suppose that instead of attenuating the mid-range, we try to bring up bass efficiency by making the cone move more air. There are three practical ways to do this:

1. Use more than one loudspeaker. Some of the finest custom installations employ banks of four or more high-efficiency loudspeakers for really impressive bass reproduction.
2. Use the speaker to drive an exponential horn. A full-size horn, however, must be immense to reproduce really low frequencies efficiently. Even the size reduction allowed by corner placement does not result in an inconspicuous piece of furniture. Fig. 5 shows the construction of a rear-loading theater horn which houses two high-efficiency 15-inch drivers.
3. Mount the loudspeaker in a matched reflex enclosure. A correctly designed reflex enclosure adds considerable air loading to the cone in the 30- to 60-cycle region. If everything is properly worked out, the cone doesn't have to move any farther at 50 cps than it does at 500 cps to generate the same sound intensity.

But even reflex enclosures must be fairly large. About 5 cubic feet is the minimum internal volume which will achieve good bass balance from an efficient 15" speaker.

For those who have very little space available and still want quality sound reproduction, some other type of system must be found. Suppose we take a low-efficiency speaker such as that of *B* in Fig. 1 and make the cone suspension so compliant that its free-air resonance lies in the 15-20 cps region. We now install this speaker in a fairly small sealed box.

The springiness of the air trapped in the box will add to the springiness of the speaker's mechanical suspension. But the loudspeaker can't tell the difference between mechanical stiffness and pneumatic stiffness—springiness is springiness. So it behaves exactly as if it had a higher resonant frequency and were mounted on an infinite baffle.

In such a system, the mass and compliance of the loudspeaker cone assembly must be established in relation to the internal volume of the enclosure. A 10-inch speaker in a one-cubic-foot enclosure can be made to have smooth bass response down to 35 or 40 cps if desired.

This sounds impressive, but it doesn't tell the whole story. The maximum efficiency which can be achieved in the low bass region is still a function of the size of the cone, and a 10" cone has to move awfully far to generate much sound at 40 cps. In practice, the speaker is at an even greater disadvantage since the effective cone diameter is always less than the rated size. A 10-inch speaker usually has an effective radiating diameter of about 8½ inches.

The advantage of a large radiating area is clearly demonstrated in Fig. 2. The curves show the free-field response of two high-quality woofers, both designed for closed box installation. The 10-inch speaker is mounted in a 1.2-cubic-foot enclosure and the 15-inch unit is mounted in a 6-cubic-foot enclosure. Note that with the same power input the 15" speaker is about 4 db more efficient than the smaller unit.

In terms of power requirements, 12 watts into the small speaker will produce the same sound intensity as only 5 watts in the big speaker.

If we lighten the cone of the smaller speaker so that its mid-range efficiency is 4 db higher, bass response will seem thin by comparison. In relation to efficiency at 500 cps, bass will start to droop around 80 cps instead of 50 cps.

So, if a loudspeaker is to be designed for use in a small box, the choice has to be made between efficiency and the usable low-frequency limit. And no matter how the various factors are juggled, the efficiency of this type of high-fidelity loudspeaker system re-

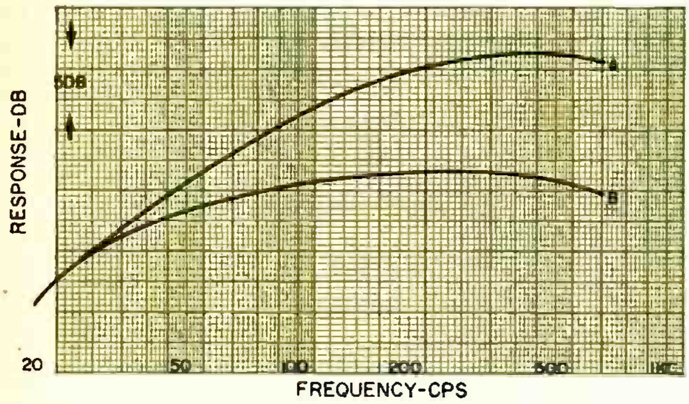


Fig. 1. Comparison of high-efficiency (A) and low-efficiency (B) loudspeakers which have been mounted on infinite baffles.

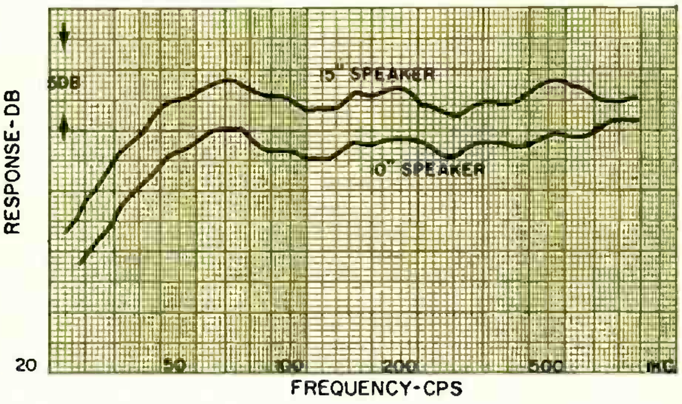


Fig. 2. Comparative responses of 10" and 15" loudspeakers showing the advantage to be gained by larger radiating area.

Fig. 3. Medium-efficiency 8" speaker in 1 cubic foot enclosure.

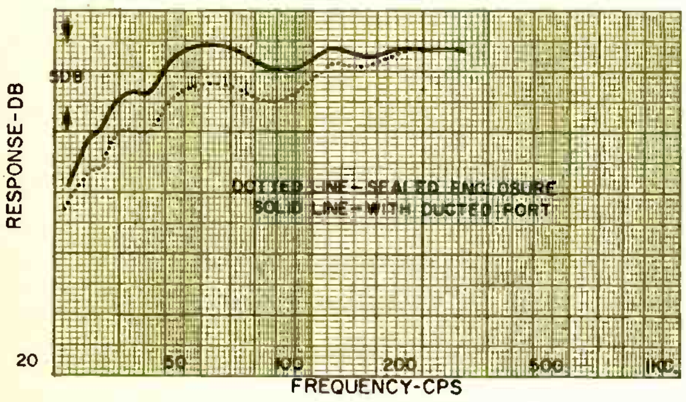
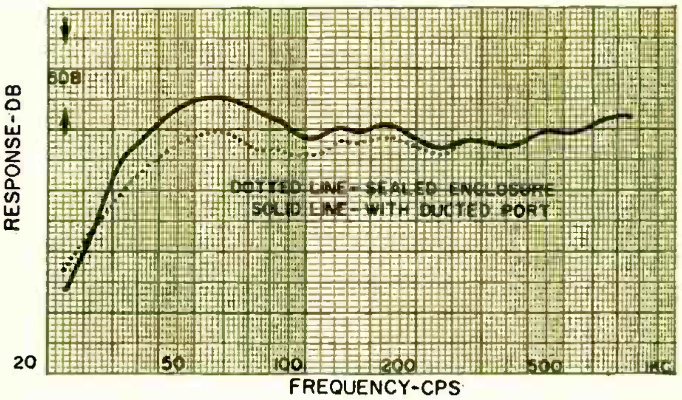


Fig. 4. Ten-inch speaker response in a 1.2 cubic foot enclosure.



mains comparatively low at best.

Adding a Vent

You may ask, since a reflex enclosure enables us to get good bass from a high-efficiency system, why can't we put a vent in a small box to raise efficiency?

We can. But the area of the port has to be quite small (even with an added duct) to tune the cabinet to the optimum frequency. When port area is considerably smaller than cone area, the increased radiation at low frequencies is quite a bit less than that realized from more conventional reflex designs. Nevertheless, a useful gain in bass efficiency can often be achieved.

Fig. 3 shows the response of a small commercial system using a full-range 8-inch loudspeaker in a one-cubic-foot enclosure. The system was measured in a fairly large listening room. Note that the ducted port in this system clearly improves performance through the 40-100 cps region. Porting the cabinet is actually doubly worthwhile because both bass efficiency and power handling ability are increased.

If we try the same technique with the 10-inch woofer in its 1.2-cubic-foot enclosure a similar usable increase in bass efficiency is realized. Fig. 4 shows the response of this combination with and without a small ducted port. The added radiation from the port gives a little hump in bass response around 60 cps.

The bump can be smoothed out by making the speaker a little more efficient, bringing up the response above 100 cps. In commercial practice, however, the bump is more apt to be left in at the expense of over-all efficiency. Speaker manufacturers have learned the truth of the comment that most people like the sound of a little bump in the bass as long as the advertising copy assures them that the speaker is "really" flat.

This discussion of low-efficiency systems does not begin to cover all the design factors involved, but it should help to clarify two important points:

1. There is no magic in the design of small low-frequency loudspeaker systems. The basic characteristics are determined by physical laws which stubbornly refuse to change.
2. Extended bass response in a small loudspeaker system is always achieved at the expense of over-all efficiency.

In connection with the latter point, it should be emphasized again that there is a difference between "necessarily inefficient" and "wasteful." Some bookshelf speaker systems are inefficient simply because they are wasteful. It is extremely important that all design factors be carefully correlated for optimum results, and that extremely close tolerances are imposed during manufacture. A *Cadillac* uses more gasoline than a *Volkswagen*, but a car which gets less than 40 miles to the gallon is not necessarily a *Cadillac*.

The main differences between low- and high-efficiency loudspeaker systems should now be clear. To sum up thus far:

A high-efficiency system raises bass efficiency by utilizing some sort of additional acoustic loading.

A low-efficiency system accepts the limitations of the unaided speaker at low frequencies. The efficiency of the rest of its range is deliberately reduced in proportion.

Amplifier Power

While a good 30-watt amplifier is ordinarily adequate to drive an inefficient loudspeaker in a home installation, the overload margin is not great. Instantaneous peaks in ordinary program material can easily reach the equivalent of 15 or 20 watts, even at "normal" listening level. Consequently, the overload characteristics of the amplifier are important when it is used to drive a low-efficiency loudspeaker. If the amplifier recovers from overload quickly and smoothly, chances are that such momentary peaks will not be heard as distortion even when the peak power rating is exceeded. But if the amplifier goes to pieces when overdriven, all sorts of audible mush will be heard when the system is pushed too hard.

Since the efficient loudspeaker system delivers the same listening level at a fraction of the power input, amplifier characteristics are not so critical. In an actual test, a 50-watt high-quality amplifier was used to drive one of the small low-efficiency speakers and the gain turned up until musical peaks were overloading the amplifier. The speaker was then replaced by a highly efficient corner horn and the system run at the same loudness. Under the latter condition, instantaneous peaks required less than the equivalent of 4 watts from the amplifier!

This important difference in power requirements is indirectly responsible for a difference in dynamic range as well. A loudspeaker can be built to take just so much electrical power. Even though a low-efficiency speaker may be capable of long cone travel, it cannot generate the audible intensity of a high-efficiency system; the great amount of power required for high intensity may damage the voice coil. Consequently, even with unlimited electrical power available, the dynamic range of a small speaker system cannot approach that of a good big system.

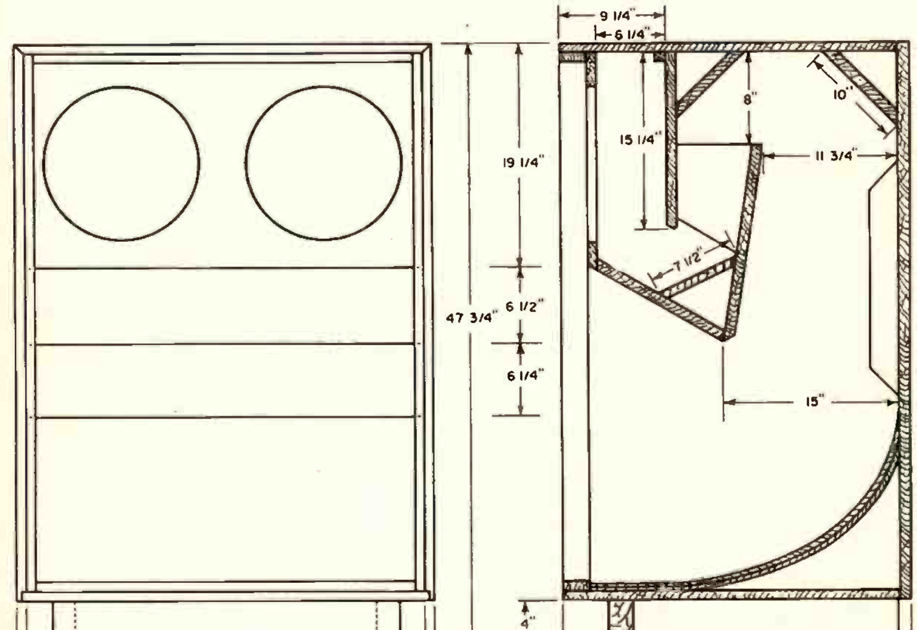
In fairness, this limitation in dynamic range is of little interest to many listeners. At "average" loudness, neither type of system is apt to be momentarily overloaded. But the difference can be easily demonstrated under the right conditions. The man who wants to hear the smash of cymbals, the "bite" of a *Steinway* grand, at full concert intensity, will not be able to duplicate these sounds readily with a bookshelf-type loudspeaker system.

"This is all very interesting, no doubt," says the prospective customer, "but you still haven't told me which type of system is better."

The answer is that if all other considerations can be ignored, a good big system is almost always better than a good small system.

An interesting trend recently has been the introduction of new loudspeaker systems which make the best of both design philosophies. A 15-inch medium-efficiency woofer capable of long linear cone excursions can generate really awesome bass in an enclosure no larger than 6 cubic feet. In conjunction with matched high-frequency transducers, this makes a deluxe speaker system which, while not "bookshelf size," is not inordinately large. Several manufacturers have introduced such systems and acceptance by critical listeners has been extremely good. ▲

Fig. 5. A rear-loading J. B. Lansing theater horn which will bring out the full bass capabilities of a pair of fifteen-inch high-efficiency bass drivers.



CB ANTENNA MATCHING

By LEO G. SANDS

You can get the most out of your CB rig's low power by proper matching. Here are some practical suggestions.

TO GET maximum range from your Citizens Band rig, you must avoid waste of power. Since the FCC limits transmitter power to 5 watts (plate input), you can make most effective use of the limited power by channeling as much of it as possible into the antenna.

The only "useful" power is that which is radiated by the antenna. You can lose power through transmission-line attenuation and/or antenna mismatch.

Two variables, the antenna input impedance and the transmitter output impedance, must be taken into account. The characteristic impedance of the transmission line (usually 50-ohm coaxial cable) remains fixed, irrespective of its length. However, the longer the transmission line, the greater the transmission loss due to leakage and conductor resistance.

Maximum transfer of energy takes place when the impedance of the generator (transmitter) matches the impedance of the load (antenna). Connecting the generator to the load is the transmission line, which is not 100% efficient. The system is most efficient, however, when the transmission line is terminated by a load whose impedance is of the same value as its own characteristic impedance.

If there is an impedance mismatch, part of the transmitted power is reflected back from the antenna to the transmitter is not absorbed and then radiated by the antenna. Mismatch causes standing waves of voltage and current along the line. A measurement of the amplitude of the voltage or current at a point of maximum value (loop) compared to the amplitude at an adjacent point of minimum value (node) yields the standing-wave ratio (SWR) of the system. The higher the standing-wave ratio, which increases with the degree of mismatch, the greater the power loss as far as the antenna is concerned.

Transmission Line Losses

The transmission line used for mobile installations is generally Type RG-58/U coaxial cable which has a characteristic impedance of about 50 ohms. This matches the nominal impedance of most quarter-wave whip antennas. The cable's attenuation loss is 2.6 db per 100 feet. In a 20-foot length, the loss should be only .5 db, which represents a power loss of 10%. If the transmitter delivers 2.5 watts output (50% efficient transmitter), the antenna will receive 2.25 watts. Only .25 watt is lost. This is true, however, only when the SWR is 1. This is seldom the case in actual practice.

If there is a 50% mismatch (cable = 50 ohms, antenna = 25 ohms), the SWR is 2 since $SWR = Z_o / Z_L$ where Z_o = cable impedance and Z_L = antenna impedance. When the SWR is 2, the transmission line power loss is increased 25%. If the power loss with an SWR of 1 is .25 watt, the loss when the SWR is 2 amounts to .31 watt. The curve of Fig. 1 notes the per-cent increase in power loss for various values of SWR.

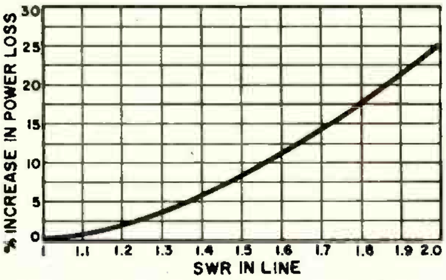


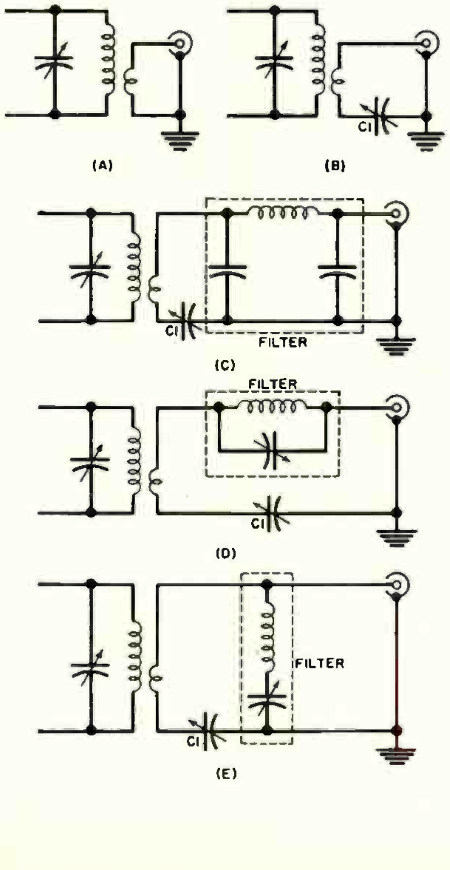
Fig. 1. The effect of SWR on power loss according to Andrew Corporation's data.

Transmitter Output Circuits

The antenna input impedance is a variable which depends mainly on antenna length in relation to operating frequency and, to a lesser degree, on its diameter and ground plane. The other variable, the transmitter output impedance, can also be adjusted.

Various transmitter output circuits are shown in Fig. 2. In the circuit of Fig. 2A, the r.f. amplifier tank-tuning capacitor also tunes the antenna circuit indirectly through transformer reflection. The circuit of Fig. 2B is quite commonly used in CB tests. Capacitor C_1 is tuned for maximum transmitter output. At optimum setting, C_1 tunes out the antenna reactance so that the antenna appears as a purely resistive load.

Fig. 2. Common transmitter output circuits.



The circuits shown in the other parts include filters for suppressing undesired harmonics which could cause interference to TV reception. In Figs. 2C, 2D, and 2E, capacitor C_1 is used for matching the transmitter to the antenna system. In Fig. 2C, the filter is a low-pass type which cuts off signals at frequencies above 42 mc. or other predetermined value. The parallel-resonant wavetrap in Fig. 2D presents an extremely high impedance to the transmitter's second harmonic (around 54 mc.), while the series-resonant wavetrap short-circuits the harmonic to ground. Neither has any significant effect on the 27-mc. transmission.

Antenna Circuit Tuning

To tune any of these circuits so as to obtain the best possible antenna match, a field-strength meter or a bi-directional r.f. power meter is helpful.

When a field-strength meter is used, it should be placed as far from the antenna as its sensitivity will permit. Alternately adjust the r.f. amplifier tank tuning and the antenna trimmer for highest field-strength meter reading with the transmitter turned on.

To avoid variables which can cause error, let no one stand between the antenna and the field-strength meter—or even near them. Don't make these adjustments for prolonged periods and never when the channel is in use.

A better method is to use a bi-directional r.f. power meter. Laboratory-quality instruments of this type cost more than $100.00, but less precise (and less expensive) devices for this purpose are also available.

The meter is inserted between the transmitter antenna socket and the transmission line. If the instrument is calibrated in watts, it is set to measure "incident" power and the transmitter is tuned for maximum power indication. Then the instrument is set to measure "reflected" power, and the transmitter is re-tuned for minimum power indication. The procedure is repeated until maximum "incident" power and minimum "reflected" power readings are obtained.

The "incident" power reading is the amount of power delivered by the transmitter. "Reflected" power is the amount

(Continued on page 81)

AMATEUR TRANSMITTING TUBE TESTING

Use a slightly modified output stage of an amateur radio transmitter for simple static tests of emission, and a properly operating rig for the dynamic tests.

By **RICHARD A. GENAILLE, K4ZGM**

PERHAPS the majority of active hams have wished, at one time or another, that they could make some simple tests of their transmitting tubes—which are of the type that cannot be tested on the usual tube tester used for ordinary receiving tubes. Much has been published concerning the testing of regular receiving tubes and almost every ham has access to or owns a reasonably good tube tester for checking such tubes. Even those who don't have access to a tube tester usually have a fairly good stock of receiving tubes on hand which makes substitution feasible. Tracing troubles due to receiving-type tube failures has become a fairly simple process. Solving problems caused by defective transmitting tubes and testing these tubes is not nearly so simple.

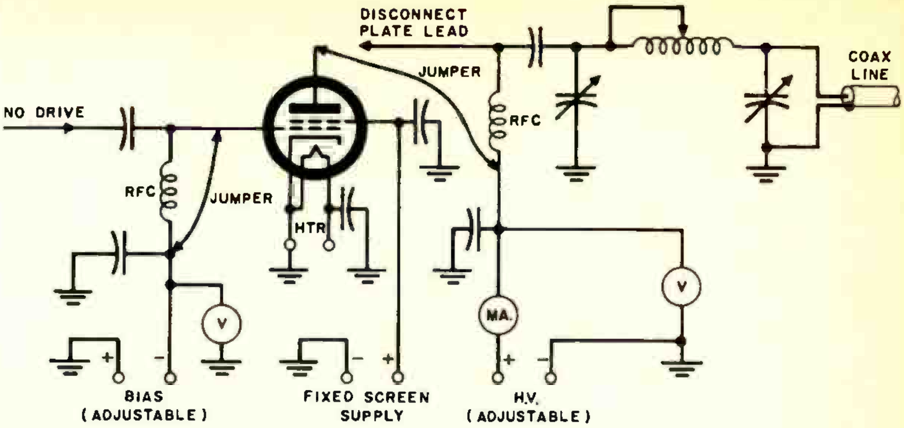


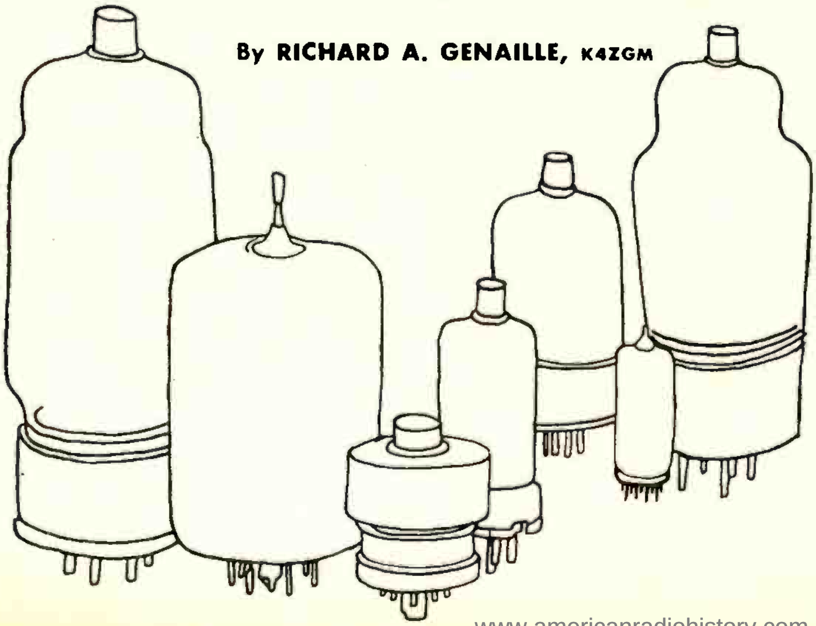
Fig. 1. Modifications of the plate circuit of a final power-amplifier stage of a ham transmitter to permit the static testing of the transmitting tube.

Very little information has appeared in the literature concerning the testing of transmitter tubes. The author found this to be true when he attempted to determine what tests, if any, could be performed to check the condition of the various transmitting tubes in his rig. Out of curiosity, more than anything else, letters were dispatched to several manufacturers asking for their recommendations in making some simple tests on transmitting tubes. The response was quite disappointing. Only one manufacturer made any attempt to provide testing information which, while not conclusive, would help somewhat.

One manufacturer provided a bundle of literature useful for designing and building transmitters and many brochures and data sheets on ham-type transmitting tubes produced by the company. As to testing transmitting tubes, his response was brief and to the point—"There is no simple way of testing transmitting tubes." This statement is so true for reasons which will be discussed later; however what dyed-in-the-wool ham would throw up his hands and quit trying even with so little encouragement.

The purpose of this article is to acquaint the large majority of ham newcomers (and maybe a few Old Timers) with the problems involved in testing transmitting tubes and to illustrate several simple tests which the average ham can make to determine whether or not his final amplifier tube is on the down-hill run. In any case, the results of the tests may help to get one's thinking on the right track.

There are two basic methods of testing a tube. One is static or emission testing and the other is dynamic testing. Since tube testers or checkers for performing these tests on transmitting tubes are not readily available, one must improvise his own tube tester. For static testing we will use the station transmitter, with slight modification, or a simple circuit which will permit the tests to be performed on the workbench. For dynamic testing, we will use a properly operating transmitter—either our own or one belonging to a fellow ham.



Static Testing

Static testing is no doubt the simplest means for gathering data on the particular tube under test. The tube data sheets, which are available from tube manufacturers for each of the receiving or transmitting tubes they manufacture, usually contain graphs prepared from data collected at the factory by static testing. These graphs may be labeled "Average Plate Characteristics," "Constant Grid Voltage Characteristics," or "Constant Current Characteristics," depending on the manner in which the static testing was performed.

In the static test, the final amplifier tube to be tested may be left in the transmitter and the final amplifier circuit temporarily modified, as shown in Figs. 1 and 2. The final amplifier must be capable of operating free from parasitics or other self oscillations and be capable of being operated with no grid drive or plate load. A means must be available for applying grid voltage and plate voltage in discrete steps. A plate supply controlled by a variable autotransformer and a variable grid-bias supply are desirable, but not absolutely necessary.

The plate voltage may be varied in steps by placing standard 117-volt light bulbs of different wattage ratings in series with the plate-transformer primary winding. The grid voltage may be supplied by one or more batteries with a number of taps (such as the *Burgess* No. 5156 or equivalent). The *Burgess*

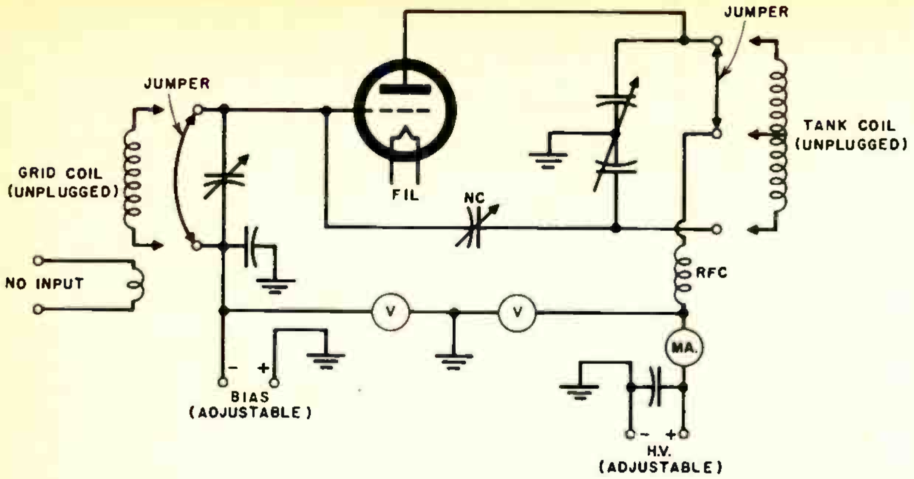


Fig. 2. Modification of a conventional triode final amplifier to permit static testing.

unit has taps at 6, 12, 13½, 16½, 18, 19½, and 22½ volts.

If one wishes to perform the static tests on the workbench and avoid modifying the transmitter, the simple circuits shown in Figs. 3 and 4 may be used. The same sources of voltage suggested for Figs. 1 and 2 may be used in these circuits. In addition, a source of filament voltage must be provided as well as a socket for the particular tube to be tested. Several current and voltage meters will also be required, plus a few clip leads for interconnecting the various components. Commonly used transmitting tubes and their respective sockets are listed in Table 1 which may be helpful in determining the socket required for the bench tester.

Just which of the voltages applied in the static test are varied in steps and which are held constant is dependent upon which of the tube characteristic curves have been provided by the manufacturer in the tube data sheets. In some instances grid voltage *versus* plate current curves are available where the plate voltage is held constant and the grid voltage is varied in steps. For each change in grid voltage away from cutoff there will be a change in plate current. The corresponding graph is plotted with the plate current along the vertical or "Y" axis while the grid voltage is plotted along the horizontal or "X" axis.

Rather than prepare a new set of graphs and curves, one can plot a new family of curves, using the data collected for this particular static test, on the manufacturer's graphs. In this manner, the original curves can be compared with the ones obtained in testing. If the set made by bench test is identical to that prepared by the tube manufacturer, it is reasonable to assume that the emission of the tube under test compares favorably with that of a new tube. This, however, does not guarantee that the tube will perform correctly under load in regular transmitter operation.

A typical procedure for plotting grid voltage *versus* plate current would be to start with approximately 25% of the maximum rated plate voltage for the particular tube with cut-off bias applied. The bias should be slowly dropped until a reading of approximately 10% of the rated plate current is obtained. Mark the grid voltage reading and the plate current reading on the graph. Next, drop the bias so that approximately 50% of rated plate current is obtained and plot the voltage readings. Do the same thing for 75% of rated plate current. With the various values of grid voltage and plate current recorded, raise the plate voltage to another level, say 50%, and follow the same procedure, marking the points on the graph as you go along. Sufficient data should be obtained to reveal whether or not the tube under test meets the published curves.

If tetrodes are being tested, care must be exercised to insure that the plate voltage applied to the tube is, when at its minimum, at least 100 volts above the screen voltage or excessive screen currents will flow. The various voltages used in performing the static tests should be checked frequently to insure that power supply regulation does not cause a change in voltage settings.

If the characteristic curves provided in the tube data sheets are "Average Plate Characteristics" or "Constant Grid Voltage Characteristics," one will find plate current plotted along the vertical axis of the graph while plate voltage will be plotted along the horizontal axis. For this set of curves the grid voltage can be set at cut-off and the voltage raised in steps from a low level up to the rated plate voltage. For each step in plate voltage a current reading is obtained. The plate voltage and the plate current are recorded and used to plot one curve for each given value of grid voltage. The bias voltage on the grid is dropped to a new value and the same procedure followed. The various readings can again be plotted on the published curves and compared to the curves for a new tube.

Table 1. Commonly used tubes and their sockets.

REGULAR 4-PIN	T-20, 3C24, 809, T-40, 35T, T-55, 811, 812, 5514, 8005, V-70D
GIANT 5-PIN	4-125A, 4-250A, 4-400A
SPECIAL 7-PIN	4-65A, 826, 829, 832, 3E29, 4D32
JUMBO 4-PIN	805, 810
JUMBO 7-PIN	813, 4E27/8001
MEDIUM 5-PIN	807
MEDIUM 7-PIN	1625
OCTAL	2E26, 6L6, 6146, 815

Once again the comparison of curves may be useful in helping the ham to make an educated guess as to what may be expected from the tube under test. Curves that do not come up to the published curves may mean that the tube under test does not meet the parameters of a new tube.

Dynamic Testing

There is no simple and convenient method for the average ham to perform the type of dynamic testing done by the manufacturer of the transmitting tube. The nearest approach to dynamic testing that the ham can perform is to test the tube in a properly operating transmitter under regular operating conditions.

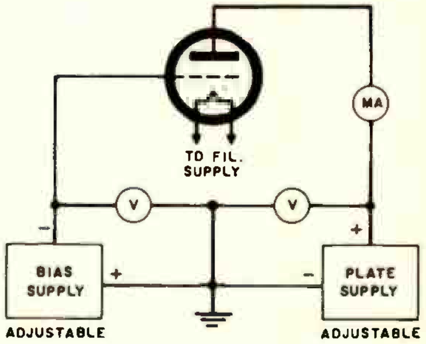


Fig. 3. Circuit for static testing triodes.

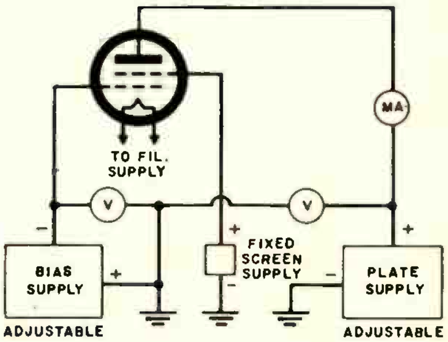


Fig. 4. Circuit for static testing tetrodes.

Actually, the most reliable test of a transmitting tube is how it behaves under dynamic or actual operating conditions. In almost all of the normal applications of a transmitting tube, a.c. or some rapidly varying potentials are superimposed on the d.c. potentials. The useful property of the final amplifier is its ability to amplify small voltage changes on the grid into comparatively large current changes in the plate circuit. The manner in which the tube reacts under these conditions is known as the dynamic characteristics of the tube.

Dynamic testing can be accomplished by tube substitution, using a transmitter as the tube tester. One can substitute a brand new tube in his own transmitter or his suspected tube in some other transmitter. This sounds quite

(*Continued on page* 105)

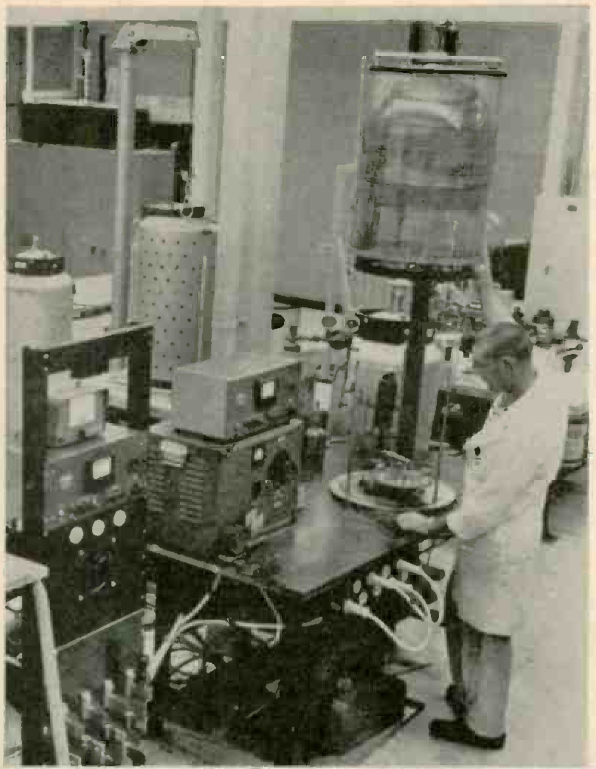
Ion Engine for Space Travel ▶

An ion engine, one form of propulsion for long trips into space, is readied for a test run in simulated space by a technician at Hughes Aircraft Co.'s *research laboratories in Malibu, Cal. The engine, developed for NASA, vaporizes a rare metal, cesium, and accelerates ionized atoms to produce an average thrust amounting to a fraction of a pound. The engine will be tested shortly in a real space flight.*

RECENT DEVELOPMENTS IN ELECTRONICS

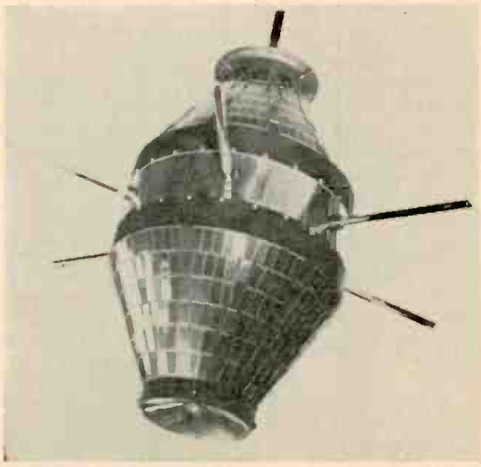
Thin-Film Research

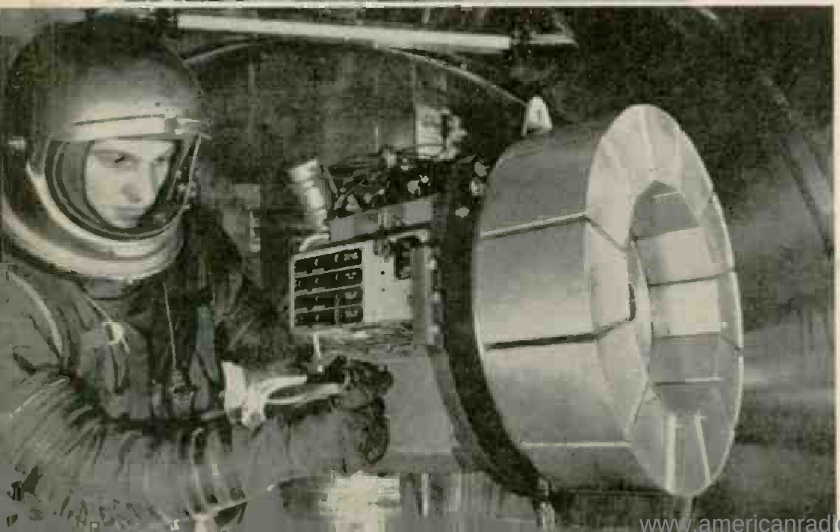
A technician in the thin-film research laboratory of the new Univac Engineering Center *in Whitpain Township, Pa., checks the results of an experiment in coating technique. Magnetic qualities of various metals when vaporized and then condensed to form a thin film on a glass plate are used in one of the firm's recent computers to provide nanosecond access time.* ▼



Topside Sounder Satellite

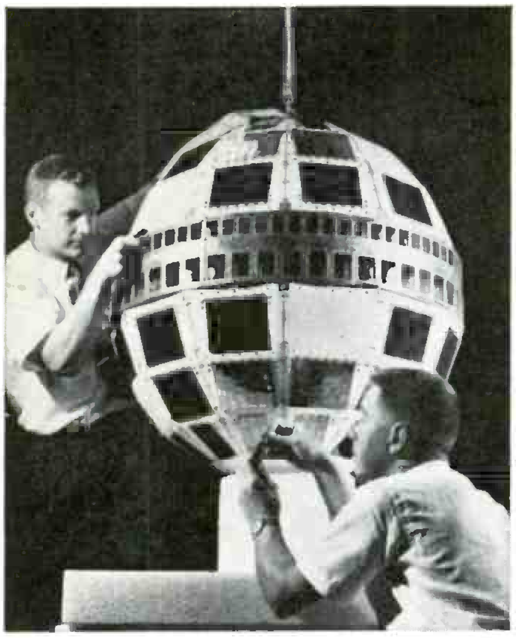
Model of the Topside Sounder satellite, designed by Airborne Instrument Lab. *and National Bureau of Standards, which is scheduled for launching in 1962. The satellite will measure the electron density of the ionosphere above the F_2 layer. Some 4000 solar cells will charge the unit's batteries.* ▼





◀ New Plasma Space Engine

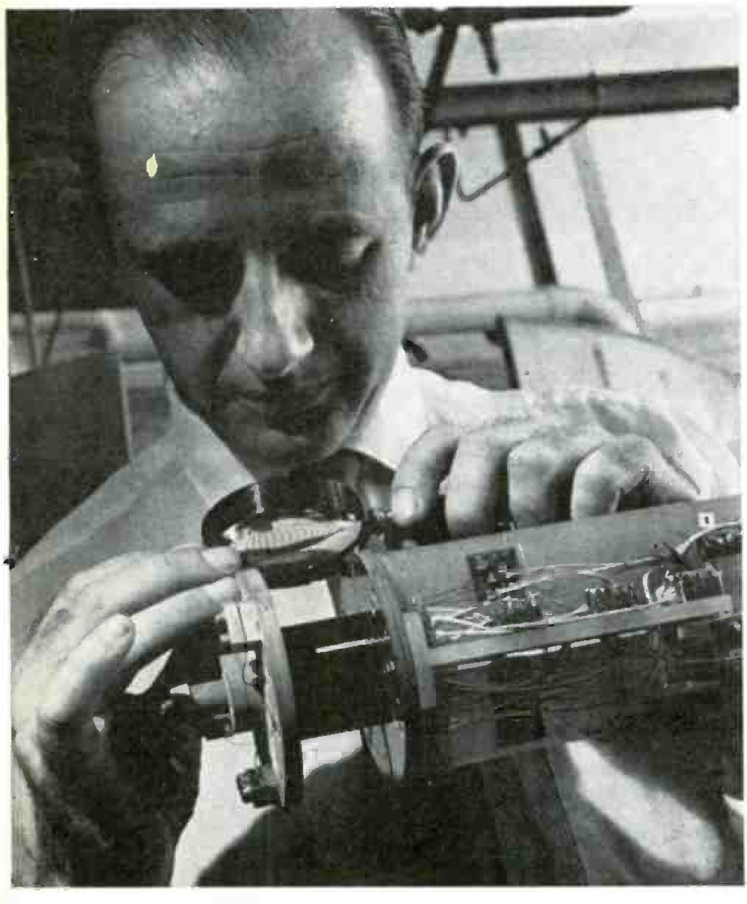
This is the first public look at a new plasma space engine said to be capable of operating for years in space. Here, in space chamber at Republic Aviation Corp., *technician makes final instrumentation adjustment in readiness for a test "run." The engine, which operates on batteries recharged by solar cells, is lab model of flyable unit the company is now building for actual space-flight tests. An electromagnetic pinch effect in a small amount of nitrogen gas produces a fraction of a pound average thrust when a high-voltage charge, stored on the bank of 12 circularly mounted capacitors, is applied to the engine's nozzle electrodes.*



▲

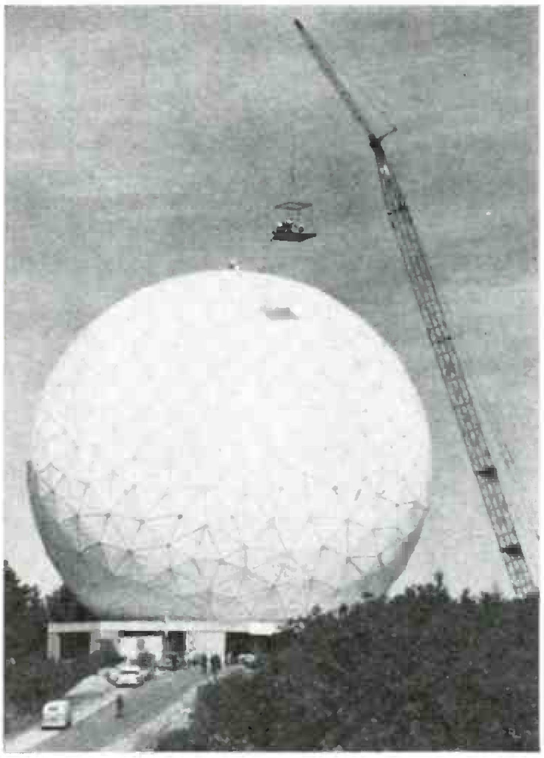
Active Communications Satellite

Technicians at Bell Telephone Laboratories *prepare a development model of an active communications satellite for special radio measurements. The 34-inch sphere, scheduled for launch into orbit this spring, will be used for experiments in the relaying of telephone calls, TV signals, and other communications overseas. Arrays of solar cells cover most of the surface. Microwave radio receiving and transmitting antennas form the belt around the middle of the satellite.*



World's Largest Radome

Workers board a platform suspended from a 250-foot crane after tightening the final bolt atop the world's largest radome, a gleaming white sphere 150 feet in diameter. Built under Air Force direction on Haystack Hill, Tyngsboro, Mass., the radome will house a sensitive communications and space-research antenna. The radome was designed by M.I.T. and built by H. I. Thompson Fiber Glass Co. ▼



◀ Superconducting Super Magnet

Scientist at Westinghouse *research laboratory is examining a 5000-turn coil of 10-mil wire made from superconducting metals niobium and zirconium. This coil, immersed in liquid helium to cool it to −450°F, carries a 20-amp current to produce a super-strength magnet whose field is twice as strong as that from a conventional iron-core electromagnet as large as an automobile and weighing 40,000 pounds.*

CCTV Monitors Drawings

With the aid of closed-circuit TV, government-contractor representatives review drawings of radar equipment to determine maintenance needs. The new G-E-developed technique televises enlarged microfilm drawings onto a number of TV monitors. Remote-control pan, tilt, and close-up adjustments are provided.

▼

Ailing Picture Tubes-Repair or Replacement?

By WALTER H. BUCHSBAUM
Industrial Consultant, ELECTRONICS WORLD

Identifying defects, determining which can be corrected, and remedying them.

THE MOST expensive item inside a TV receiver is the picture tube. The owner is as well aware of this as the man who repairs the set. Thus, when the CRT appears to be defective, a major family crisis can develop. A major decision is to be made, and the service technician is expected to play a part in reaching it: "Will replacement be necessary? Can a repair be managed instead? Or would it be best to junk the whole set altogether?"

The possible expense that may be involved is responsible for the seriousness of the situation. No wonder, then, that much ingenuity has gone into thinking up a number of dodges, over the years, that will soften or at least postpone the calamity. Rebuilt tubes are available for lower-cost replacement. There are a number of repair techniques that can be tried for certain defects. Even so, the quandary may persist. If the set is an old one in poor condition, other things may start going wrong after the expense of replacing the tube, and there will then be second guessing about whether the receiver should not have been scrapped in favor of buying a new one. A repaired tube will come to less, but it may not last long enough to warrant even that investment.

Thus it is necessary to do more than merely evaluate the defects that can cause CRT trouble to determine which can or cannot be repaired and how these repairs can be made. We will also attempt to predict the probability of success for the various techniques. Technician and owner, in the long run, must judge whether repair, replacement, or junking will be chosen; but some standards for making the choice can be worked out.

Before considering the CRT itself, the experienced technician will measure the various voltages that are applied to it by the set itself. If these are correct, he will then test the tube itself as carefully as possible, not only to determine the exact nature of the defect, if possible, but to decide whether anything can be done about it. There are inevitably certain defects that cannot be repaired or masked short of replacing the electron gun structure—which means the same as rebuilding the tube.

Types of Defects

The internal structure of a late-model CRT is shown in Fig. 1, with the relative positions of various elements illustrated. Off hand, there are a number of defects that obviously do not lend themselves to repair. The most frequent of these is an open filament. Of course, there is some chance that an externally applied voltage can weld the open ends together, but the practice is not recommended. However if the filament (or any other element) appears to be intermittent, there simply may be a loose connection inside the tube's base pin that can be repaired by re-soldering or crimping the pin carefully.

A related, mechanical defect is a loose base, which can be cemented in place. Also observable by superficial inspection is a crack in the glass, usually at the stem. This cannot be repaired. If the tube is really gassy, the familiar violet or bluish glow provides a visual indication. Nothing can be done about this either. Less obvious are shorts between various elements in the gun. These can be found with external equipment. As we will note later, there are ways of dealing with them.

Probably the most frequent deficiency to fall into the dilemma-producing category is low emission, which is also determined with an external test. It can be caused either by excessive use or contamination of the cathode coating or emitting material shown in Fig. 1. If contamination is the cause, the possibility of "rejuvenating" the active surface is good. Methods will be discussed later. If the material is depleted, little can be done to renew it. The continuous application of elevated filament voltage, as with a booster, will actually hasten the demise of the cathode, and may not do the filament itself much good. However, up to the accelerated end point of cathode life, it may force enough emission out of it to maintain usability of the tube.

Other picture tube defects fall mainly into the category of defective mechanical connections *inside* the tube envelope. The filament can be shorted to the cathode; pieces of the internal second-anode coating can flake off and lodge between elements; or an intermittent internal connection can exist between a supporting structure and the particular element to which it is attached. Such cases are far from hopeless; it is often possible to repair these defects without

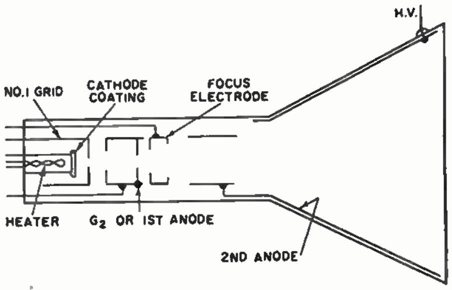


Fig. 1. Internal elements in typical CRT. Focus electrode is not always present.

Fig. 2. Model 440, by B&K, is a popular picture-tube tester and rejuvenator.

otherwise impairing the tube or shortening its life, although success cannot be guaranteed. There are often ingenious ways of working around an open connection, which would seem like an impossible situation. The required skill is mostly in recognizing the exact trouble and determining how to go about a repair.

Diagnosing Defects

A large portion of cases in which the picture tube "doesn't work" can be traced to nothing more than the loss of high voltage or a defect in the h.v. section that results in lowered second-anode potential and/or poor regulation. Before directing attention to the tube itself, then, voltages applied to it are checked. Second-anode voltage is measured first—directly at the tube itself, to begin with. The effect of manipulating the brightness control from maximum brightness to cut-off should be noted. In a well-designed, properly operating circuit, high voltage should not drop off much more than 10 per-cent with full brightness as compared to the dark-screen condition. The high-voltage check can be repeated with the CRT disconnected to see whether action is basically the same. With the load removed, there may be a slight upward shift in readings.

Next, again working at the picture tube itself, you would check other electrode potentials, such as the first anode, the first grid, the focus electrode (if present), and even the filament. The receiver schematic and the tube manual are good references for evaluation. The latter is especially useful for noting bias, which is measured directly between grid and cathode. Only after all of these voltages are found to be satisfactory can it be assumed that the picture tube itself is probably defective or "weak."

Once attention is directed to the tube itself, some further testing can be done without special instruments, but most technicians will prefer to use a special CRT checker that has the facilities for making a variety of tests. Checking for inter-element shorts is not difficult. With some other symptoms, there are problems in interpreting test results. For example, slight gassiness (no visual indication), a contaminated cathode, a depleted cathode, and a worn grid hole may all yield similar readings in an emission test. However, we would want a more specific indication before deciding what to do next.

If, under test, emission rises very slowly and then falls off rapidly when filament power is removed, this indicates either the presence of gas or considerable wear of the cathode material, rather than mere contamination. If filament voltage is temporarily raised, as in many rejuvenation methods, a gassy tube will quickly drop back to read "weak" or "bad" on the emission indicator after heater voltage is returned to normal; whereas a CRT with a worn cathode will maintain its increased emission for a while, then drop down slowly. If the cause of poor emission is merely cathode contamination, elevating the filament voltage will begin to boil off the impurities on the cathode surface and there should be some indication of a continued increase in emission when normal heater voltage is restored. This technique of boosting the heater, of course, is one way of restoring a CRT with a contaminated cathode.

Even where slight gassiness or cathode wear rather than contamination is the cause of weak emission, operation at increased heater voltage (that is, use of a booster) may permit acceptable use of the tube for many additional months. Small amounts of gas are sometimes neutralized by the effects of higher temperature. Where cathode wear is present, increased voltage and heat encourage the filament itself to emit some electrons, which bolster those issuing from the cathode.

Fig. 3. Another widely used, all-purpose tester and rejuvenator, SICO's Model 83A.

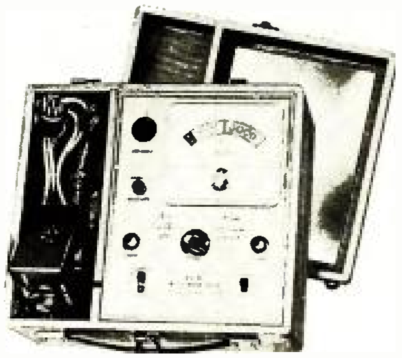


Fig. 4. Mercury's versatile Model 800 also has testing and remedial functions.

The type of detailed testing referred to here can be performed with any one of a number of commercially available checkers. The three of them shown with this article also include rejuvenating functions. The *B&K* Model 440 is shown in Fig. 2, the *SICO* Model 83A in Fig. 3, and the *Mercury* Model 800 in Fig. 4. To give an idea of how some of the test functions are arranged, the schematic of the last-named tester is shown in Fig. 5.

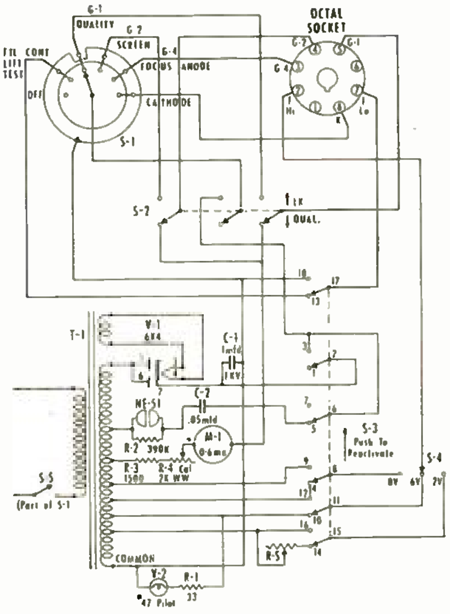
The test for leakage (inter-element shorts) in the Model 800 simply connects all tube elements together except the one singled out for test. If the neon indicator lights, there is a short between the element in question and some one of the others. Since it is helpful to know which the other element is, the test is simply repeated for each electrode until another is shown to indicate shorting.

Emission, indicated on the meter, is measured as the current between the cathode and the second grid, also called the first anode. This arrangement is also used for the life-expectancy test in the Model 800. Filament voltage is turned off and indication is observed on the emission scale. The manufacturer suggests that, if the reading drops to "bad" in less than four seconds, the tube is hopeless. If this drop-off takes between four and eight seconds, life expectancy is fair. Where more than eight seconds occur before the meter pointer falls into the "bad" region, the future outlook is encouraging. In other words, if there were to be some question as to whether rejuvenation or repair of some other defect is worth attempting, this expectancy test would enter into the evaluation.

Obviously the timing recommendations just given are somewhat arbitrary. Nevertheless, some standards are needed, and such a system often relieves the technician of the responsibility for pronouncing judgment. He can honestly explain the system to the customer and let the instrument decide. In any event, the timing standards are helpful in deciding whether gas, cathode depletion, or cathode contamination has been responsible for the decreased emission, as suggested earlier. This decision will not only help in determining whether an attempt at improvement should be made, but may also affect the choice of the method to be used.

The possibility of an open element or connection is also something of a problem. Where such a condition is indicated, it may exist outside the glass envelope, as in the tube base or connecting to the latter. Where no emission whatever is noted on a test, for example, either the grid or the cathode may be open. If the break is in the tube envelope rather than outside it, careful visual inspection of the neck may show up the open connection. Even such internal breaks leave

Fig. 5. Variety of available facilities is seen in schematic for the Mercury 800.



open some possibility of salvage. Welds can be attempted. In some cases, an external change can compensate for a break.

Rejuvenation

Two principal methods are used to restore emission in a picture tube. One, already mentioned, is that of applying a higher heater voltage for a prescribed period to increase cathode temperature and thereby "boil off" contamination. The other is the so-called "shot" method, in which a short-term, high-voltage pulse is applied between grid and cathode. The resultant momentary but large flow of current "burns off" impurities.

Each method involves some dangers. The shot method may cause total cathode failure, or the arc that occurs during the pulse duration may damage some other part of the electron gun. The strain of elevated voltage may cause a heater to open. These possibilities must be spelled out to the set owner. In either case, however, nothing is lost if the tube is not in useful condition before the try at improvement. This point is also made to the owner. The decision to go ahead with an attempt, of course, is his.

The technician actually has his choice of either method. Some tester-reactivators have built-in facilities for both. If that is not the case, either method can be applied in some other way. A filament booster can be used for the elevated-voltage method. For the shot method, the high-voltage supply of the set can be employed between grid and cathode, with the high-voltage lead momentarily touched to one of the electrodes to simulate a brief pulse.

In the author's opinion, the filament-boost method is best used on tubes that indicate a good chance for rejuvenation on emission and life-expectancy tests. If the outlook is only fair (as in the 4-8 second category mentioned earlier), trying the shot method first to gain whatever improvement it will provide is most profitable.

When the latter is used, emission should be noted before the attempt and again immediately after the first shot. If any improvement has been obtained, another shot can be tried. If adequate emission is not realized after three or at most four shots, further efforts in this direction are probably just a waste of time.

The boosted-filament method is more time-consuming, generally taking 15 to 30 minutes if it works. After the first 10 minutes, emission should be measured with normal voltage to see whether there has been any improvement. If some progress is evident, the attempt is worth continuing. As a rule, one cannot expect much increase in emission beyond the reading observed after the first 20 minutes. There are some cases in which the shot method will succeed after the filament technique has failed.

If true rejuvenation cannot be achieved, but the higher heater voltage manages to bring emission to an acceptable level, many technicians or set owners will settle for installing a permanent filament booster. As a rule, this is nothing more than a small step-up transformer that applies something like 9 volts to the heater at the expense of somewhat greater current from the 6-volt filament supply. At least, this is how a booster for parallel-filament circuits works. Where a series-filament receiver is involved, a specially designed booster for such a circuit should be used. This type is generally a step-down transformer, in which a still higher voltage is reduced to about 9 volts with increased current, but current in the primary is the same as that for which the series heaters are rated. The upset in voltages in the string of series heaters is not serious, since it is only a small percentage of total heater voltage, which adds up to line voltage.

Fig. 6. "Universal" external restorer that can boost filaments or compensate for certain shorted or open conditions.

One particular booster, the *Perma-Power* Model K101, is shown in Fig. 6. It is used as an example because it is of the so-called "universal" types. It can be connected for either parallel or series circuits and it also provides several other facilities, which we will discuss soon.

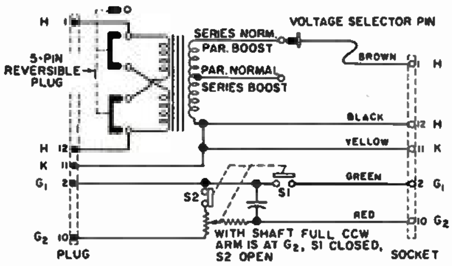
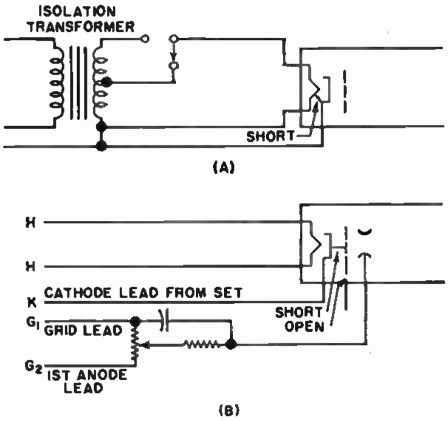


Fig. 7. Circuit of restorer in Fig. 6.

Fig. 8. Two ways in which a universal adapter can be used: to operate a CRT (A) with a heater-cathode short and (B) with a cathode-grid short or an open grid.



Shorts and Open Circuits

Inter-element shorts can often be repaired with the shot method already described. In this case the shot or pulse is applied between the two elements between which there is leakage in the hope that the material at the area of contact will be burned off. Where this substance is a thin flake of the anode coating material, it should disintegrate rather easily during the brief arcing. Sometimes a short can be cured simply by tapping the tube lightly and tilting it in various positions so that the foreign material is knocked out of its perch. A combination of the pulsing and tapping methods is also sometimes effective.

An open connection between an element and its lead can also be cured with the shot method quite often. Here we rely on the arc that results when the current jumps from the lead to the element to produce a weld. Even more so than in the short-elimination operation, a number of attempts may be necessary with the picture tube in different positions and with some discreet tapping. This helps to bring the two sides of the open connection in better alignment or closer contact.

Even with diligent effort, the outcome of such attempts cannot be forecast accurately. Generally speaking, the chance for success in welding connections is about one in three. As far as shorts are concerned, the shot method will work about two times in three. Before such techniques are undertaken, the customer should be informed that there is no guarantee of success, that a try is being made in the hope of saving him the cost of another picture tube, that the present one is inoperable in any case without the repair, and that failure of the method will not in any way diminish the trade-in value of the glass blank. In this way, the technician has some insurance against unjust recrimination if his efforts fail.

When certain types of shorted or open conditions exist, it is possible to restore the CRT to acceptable operation without trying a direct remedy, or after an attempt at correcting the defect has failed. This generally involves some revision of external circuitry. Rather than make circuit changes directly—after all, the defective CRT will eventually wear out and have to be replaced anyhow—it may be wiser to use one of the "universal" CRT restorers or adapters available for the purpose.

Such an all-purpose booster-restorer has already been shown in Fig. 6. In addition to the multi-tap filament transformer, it contains other circuit elements (Fig. 7) that can be introduced between external connecting leads and the CRT itself. By manipulating the position of a 5-pin plug that chooses connections to the transformer primary

(*Continued on page 67*)

INDUSTRIAL ELECTRONICS VS TV SERVICE

READERS TAKE SIDES, RAISE NEW POINTS, AND NOTE OTHER POSSIBLE ANSWERS IN RESPONSE TO AN EARLIER ARTICLE.

WHEN we published James T. Mendel's "From TV Service to Industrial Electronics" (page 34, September), we were prepared for an appreciable response from readers. We got it. The nature of the response, however, had a few surprises to offer.

After all, the subject is a bread-and-butter matter for large numbers of people employed in electronics. There was also much room for differences of opinion. Readers will recall that the author, after a long career in TV service, as employee and then shop owner, concluded he had reached a dead end. Given a job opportunity in industrial electronics, he elected to gamble. He went further, earned more, labored less, and found a better working climate. He also became an apostle seeking converts.

Reader reaction touched all bases. There was enthusiastic endorsement of Mendel's argument: many wanted advice about making the same change. Some in general agreement offered interesting qualifications of the stated viewpoint. There were also "antis," even including one who had made the switch in reverse, going into TV service. Others advanced the interesting proposition that a choice between both fields is not necessary—a man could have his cake and eat it, if he wished.

Letters came from people in either camp, industrial or service electronics, but the writer's present situation did not automatically establish the side he took. The only surprise was in the way reactions were distributed. We know many people doing well in TV service who see a great future in it and would not toss it away lightly. The expected outcry from them never developed. Opinion preponderantly favored a future in industry.

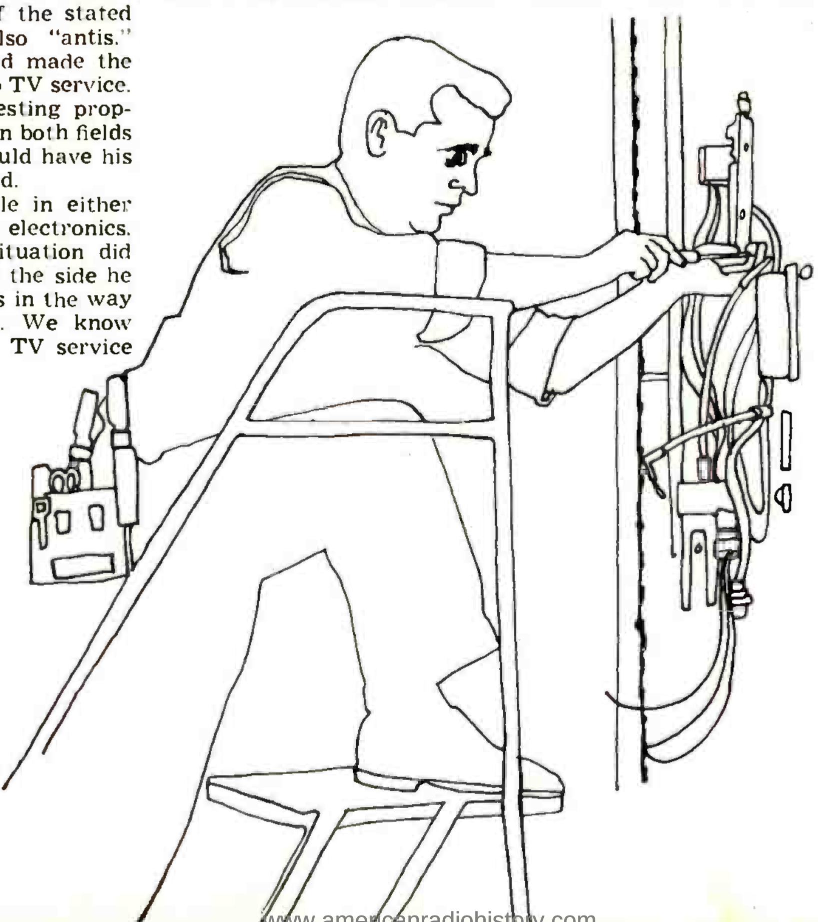
Amongst the "pros," many showed great enthusiasm. "Congratulations to Mr. Mendel," said Hubert Hammett of Henderson, Texas. L. D. Lockwood, now in the navy and "an enthusiastic follower of the growing field of industrial electronics," felt the same way. TV service technician Joe Simon of Chamberlain, South Dakota, has "had the very same opinion for quite a few years."

Many on both sides of the argument did not reduce the matter to black and white. There are many things a TV service stalwart would have to evaluate to avoid taking what might be, for him, a backward step. Acceptability to employers was a big question mark. Reader Hammett was among those who had doubts about the willingness of personnel departments to recognize the suitability of a man whose chief experience was in TV work. W. W. Wallace of Clarkton, N. C., had no doubt: "I have submitted applications several different times for work in industrial electronics. Each time the answer was about the same: no place for my particular type of training."

On this point, only time can solve the problem and we have little doubt that it will. There are still many employers who have not awakened to the excellent opportunity for *them* inherent in the pool of capable, experienced, TV-trained technicians. Others, however, actually take the initiative in seeking out such prospects. Just as this has grown in the past few years, it will continue to grow in the years ahead.

Related to this practical problem is another, that of geography. In some parts of the country—areas where electronics activity is high and few skilled candidates are available—employers have learned to exploit all avenues. Some have gone as far as advertising for technicians in other areas. In other regions, making the switch is out of the question—unless you are ready to pack your bag and move. Many have done so.

But we have only discussed "mechanical" problems so far. An impressive number of thoughtful readers raised another point, in one form or another: whether you end up a smash success or an abject failure can depend on the kind of person you are. Despite the similarity in general requirements, the specific qualifications you have to offer—and they need not be strictly technical—may foreshadow success in TV service and failure in industrial electronics, or *vice versa*.



For example, John J. Aylwin of Dallas, Texas, thinks you will need good mechanical aptitude to succeed in industrial areas: "Many a time the 'electronic' trouble can be traced to a mechanical fault, such as a cam not closing a microswitch." The point is debatable; this would not be true of all industrial positions, but is often true of independent service, as in the case of record players.

More to the point is Aylwin's opinion that "a production foreman can make a TV customer look like a plaster saint.

(*Cont'd on page* 98)

FM multiplex stereo detection methods

/ By NORMAN H. CROWHURST

How do multiplex circuits recover the original left and right signals? Different manufacturers employ different techniques—all of interest to audiophiles. Both the matrixing and switching methods are analyzed.

THE system chosen by the FCC for the transmission of FM stereo can be described in two different ways. One way is to say that the transmission consists of an L + R (left plus right) signal on the main channel and an L − R (left minus right) signal amplitude modulating a 38-kc. subcarrier. The second way is to say that the transmission is the result of time-division multiplex where first the left and then the right channels are sampled at a 38-kc. rate. Whichever description is used, the result is the same transmitted signal. How can this be? It is a sort of natural relationship, which makes another good reason for using the system: it is versatile.

MOVEMENT REPRESENTS	FORTY FIVE-FORTY FIVE		VERTICAL-LATERAL	
	LEFT	RIGHT	LATERAL	VERTICAL
LEFT ONLY	↗	•	→	↑
CENTER	↗	↘	⟶	•
RIGHT ONLY	•	↘	→	↓

Fig. 1. Table showing relative movements of stereo pickup stylus for left, center, and right signals, demonstrating that the composite can be resolved either as left and right signals at 45-45 degrees or as sum and difference signals with a lateral and a vertical motion of the stylus.

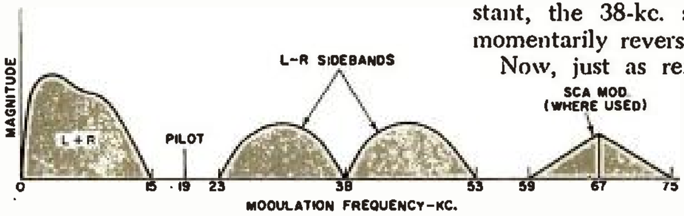


Fig. 2. Typical modulation spectrum of the multiplex system showing how pilot fits between sum and difference sidebands.

For the moment, let's take another look at stereo discs. The way we usually describe it, the left modulation is on one 45-degree wall and the right modulation is on the opposite wall. No matrixing is involved. But in terms of vertical and lateral motion, the lateral component of movement is the sum of left and right, while the vertical component is the difference (Fig. 1). Hence, matrixing has occurred in effect.

Time-division multiplex does not, in theory, involve matrixing; you just switch back and forth, at some predetermined frequency, between left and right. The 38-kc. frequency chosen for the system means that 38,000 samplings of left and 38,000 samplings of right are made in every second (Fig. 4).

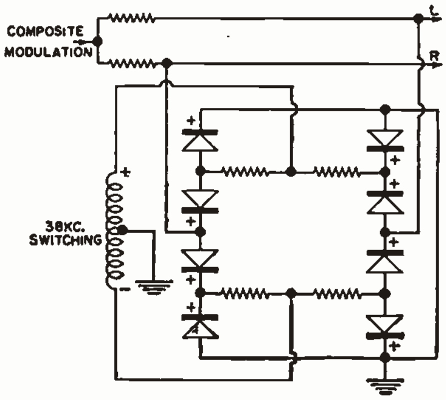
This switching notion is fine, but it involves something that looks like a 38-kc. square wave, of sorts. As is well known, a square wave can be mathematically—or graphically—analyzed into a fundamental and a series of odd harmonics. The audio on left and right would appear as sidebands of the 38-kc. square wave. So the composite signal would consist of: 38 kc. with sidebands, 114 kc. with sidebands, 190 kc. with sidebands, and so on up—slowly diminishing in magnitude.

Even the first harmonic group, 114 kc. ± 3 × 15, or 45 kc., goes up beyond the permitted sideband modulation range of an FM transmitter. To make this method acceptable, all modulation products above the fundamental must be filtered off, before the main transmitting carrier is modulated.

What this really means is that the switching is no longer like a square wave, but like a simple sine wave. In effect, the 38 kc., which you can regard as a switching frequency, adjusts itself so every positive peak is on the left waveform, and every negative peak is on the right waveform (Fig. 5). When left happens to be negative compared to right, for an instant, the 38-kc. switching frequency momentarily reverses its normal phase.

Now, just as referring 45-45 stereo discs to vertical-lateral effectively introduced matrixing, we can change our terms of reference in this composite modulation. If we filter off all frequencies above 15 kc., so as to get rid of the subcarrier or switching component, what will be left is the average of left and right, added together, or half their *sum*. If we also subtract this from the composite, leaving everything *except* the components below 15 kc., we have a suppressed-carrier modulation, which is the *difference* component. When left and right are momentarily identical, there is momentarily no 38 kc. (Fig. 6). Notice that when the waveforms shown in parts A and B of Fig. 6 are added together, the resultant is the top waveform of Fig. 5.

Fig. 3. Diodes used as switches for time-division multiplex reception. The four diodes at the left conduct when top of the 38-kc. winding is positive thus shorting right-channel output to ground. The diodes at the right are non-conducting at the same time, allowing the left-channel output to pass unattenuated. Half a cycle later, the diodes all reverse operation.

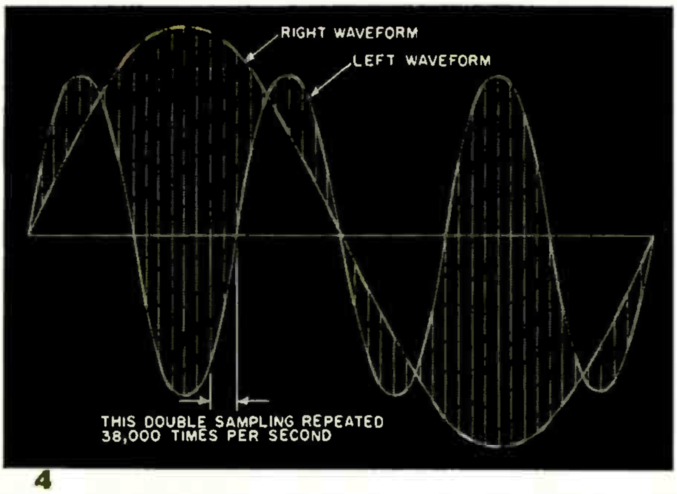


Thus the same signal can be regarded as time-division multiplex between left and right, or as suppressed-carrier multiplex of difference on the sum. All we need for reception is some means of making sure that the receiver can work in synchronism—either way—with the transmitter. Viewed as time-division multiplex, the receiver must swing back and forth at 38 kc., exactly in synchronism with the transmitter's swinging. Viewed as sum and difference matrixing, the suppressed subcarrier for the difference modulation needs re-inserting in exact synchronism.

To provide this synchronization, whichever system of reception is used, a small pilot frequency, of exactly half the subcarrier frequency—19 kc.—is transmitted along with everything else. Limiting the audio program to its useful range of 15 kc., sum components of the modulation will fall off to virtually nothing above this frequency. Similarly, sidebands of the suppressed-carrier difference modulation will drop off to virtually nothing beyond 15 kc. above and below the subcarrier frequency (Fig. 2). This conveniently leaves a nice open space for the pilot frequency, so it won't conflict, or become confused with, anything else.

To Matrix or Not to Matrix?

So now the big question is, how to make an adapter. To matrix or not to matrix? The time-division multiplex, or switching approach, has not been popular with hi-fi component manufacturers thus far, mainly because it's a "strange animal." Matrixing they know about, having experimented with it for the previously proposed *Crosby* system. But switching



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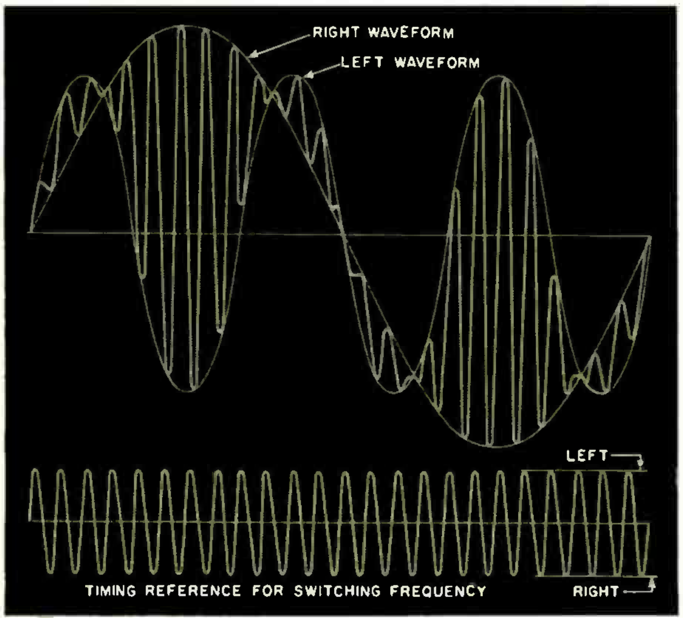

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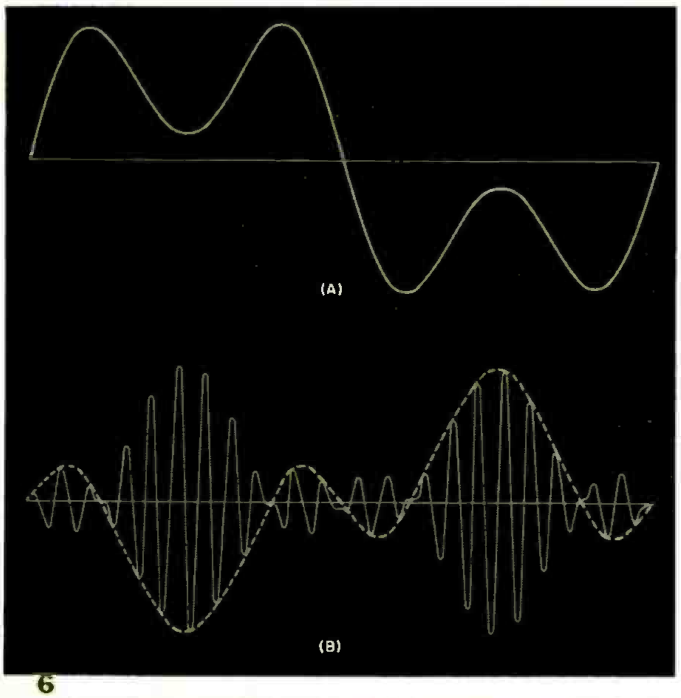

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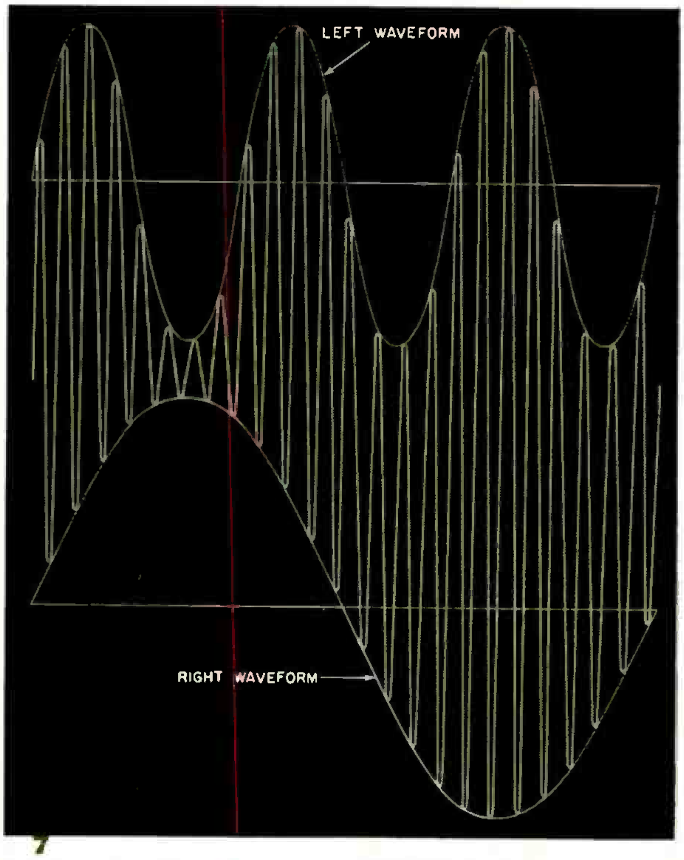
Fig. 4. In time-division multiplex the left and right signals are switched and sampled at rate of 38,000 times/second.

Fig. 5. Sinusoidal switching is employed for time-division multiplexing here. The timing waveform is also shown below.

Fig. 6. The waveform of Fig. 5 can be analyzed by simple filtering into (A) sum of left and right and (B) suppressed-carrier modulation of difference waveform (shown by the dashed line).

Fig. 7. Adding subcarrier in correct phase to the composite waveform (see Fig. 5) puts the left waveform at the top and the right waveform at the bottom of the envelope. This resultant waveform may then be applied to envelope detectors.

Fig. 8. Correct phasing between pilot and the suppressed subcarrier, as defined by the FCC transmission specifications.



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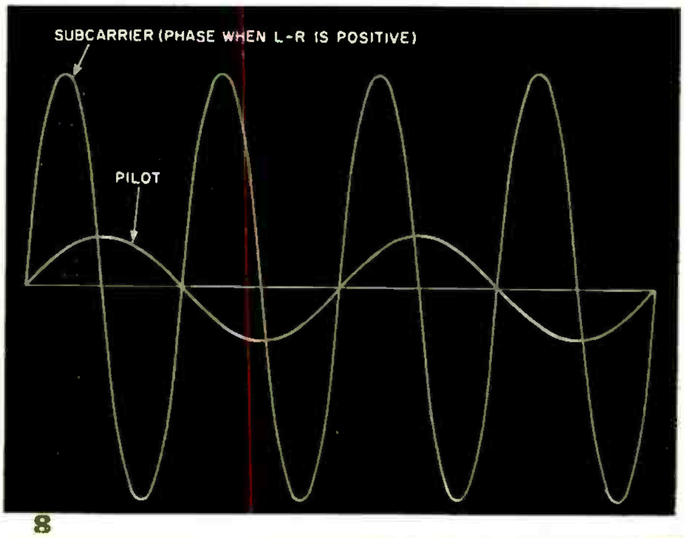

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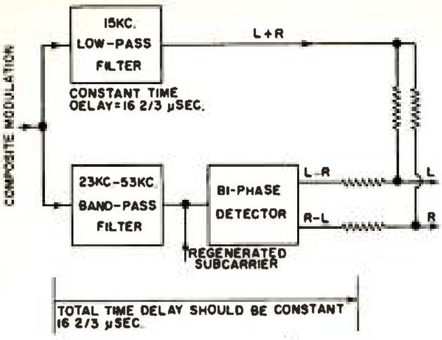


Fig. 9. Sum and difference matrix system.

techniques, such as by the use of beam-switching tubes—how can you be sure you won't be running into all kinds of distortion? That is a frequent question when the subject is raised.

To avoid unknown distortions, some have done essentially the same thing with bridges of diodes (Fig. 3). The main reason seems to be that, working against time, engineers would rather not get involved with strange animals!

To matrix properly, sum and difference signals must be kept in the correct phase relationship at all audio frequencies. Assuming the transmitter does its part of the job correctly, the receiver must separate sum from difference modulation, demodulate the difference, and then recombine the two, without introducing any time difference between the two elements (Fig. 9).

A low-pass filter, for separating the sum, can be made close to phase-linear relatively easily. Among simple filters, the so-called constant-resistance type comes closest. A phase-linear filter produces *constant time delay* to all frequencies passed by it. Now we have to get the same time delay for the difference, through its filtering and demodulation.

Here is where some problems may arise. A high-pass filter is an inversion of a low-pass filter, and a bandpass filter can be regarded either as a synthesis of low- and high-pass characteristics or as a direct derivative from the basic low-pass type. As a low-pass type can be made phase-linear, it ought to be easy to make a bandpass type that is, too. But it isn't. As a matter of fact, we don't know of any phase-linear bandpass filter with adequate bandwidth and response that will do this job perfectly.

Suppose a single audio frequency is transmitted over the left channel only. With a matrix-type receiver, there are two ways of degrading separation, so some signal leaks through into the right channel: (*a*) the subcarrier phase is incorrectly regenerated; (*b*) the matrixing is incorrect. If there is some leakage from left to right (and *vice versa*), adjusting either subcarrier phasing or matrixing will change the amount of leakage. A minimum leakage could be found by adjusting either one, but a complete null can be obtained only by careful adjustment of both.

With a matrixing system employing a bandpass filter, adjustment of both subcarrier phase and matrixing (relative amplitudes of sum and difference in the mix) can achieve virtually infinite separation *at any one audio frequency*. But, because of the lack of complete phase linearity, different adjustments will be needed for *each* audio frequency.

To cut a long story short, the circuit is, of necessity, a compromise. By carefully adjusting subcarrier phase so maximum separation is achieved at the higher audio frequencies, at the same time as matrixing is adjusted to give maximum separation at lower audio frequencies, the separation can be made fairly high all the way up (Fig. 10).

One way to improve the matrixing method is to use a subtraction circuit, instead of a bandpass (or high-pass) filter. A low-pass filter is used to isolate the sum components (Fig. 11). Now, if the subcarrier is added to the composite and the whole is demodulated with positive and negative outputs, using diode loads returned to the low-pass filter output *instead of ground*, the signal between positive and negative outputs will be a true difference. If the circuit efficiencies are such that the sum equals difference at this point, left and right outputs will appear at the positive and negative diodes—with ground as a reference—without further matrixing.

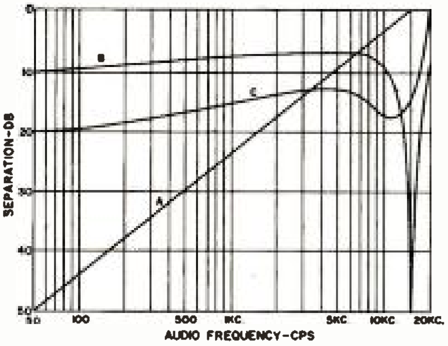


Fig. 10. Separation possibilities with arrangement of Fig. 9, using normal-type filters. (A) Theoretically correct phase and matrix adjustment, giving maximum separation at low audio frequencies. (3) Adjustment of subcarrier phase, matrixing for maximum 15-kc. separation. (C) One optimized adjustment (others are possible) to give reasonable over-all separation.

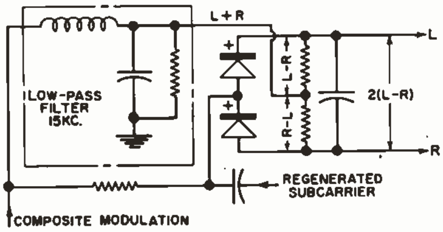


Fig. 11. Change in basic matrixing circuit that avoids need for bandpass filter. Note that diode load resistors are connected to output of the low-pass filter as a return circuit rather than to ground.

This approach has certain similarities to another new development, usually called *envelope detection*. When the subcarrier is added to the composite in its correct phase, the upper edge of the signal envelope is the left waveform, while the lower edge is the right waveform (Fig. 7). So all we really need is an efficient way to detect the top and bottom separately, without interference—and without any filters at all! Several manufacturers seem to have discovered this possibility at the same time and have come on the market with different versions of adapters which operate on this principle.

So we have three kinds of detector now in use: (*a*) switching—using either a special beam-deflection tube or diode bridge; (*b*) matrixing; and (*c*) envelope detection. In some cases a combination of two of these methods is used. For example, some matrixing may be used with a switching detector in order to produce the correct amplitude and separation of the left and right output signals.

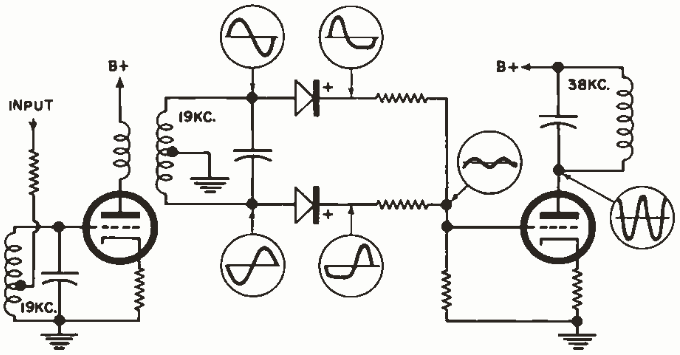
One reason for favoring the matrix circuit originally was its assumed greater flexibility for accurate adjustment. In point of fact, the switching and envelope detection circuits can also have adjustments for matrixing or separation.

Correct Phasing

Whichever circuit is used, the subcarrier (or switching frequency) has to be correctly phased *at both ends*. The FCC has laid down the correct phasing at the transmitter (Fig. 8). For proper stereo separation, the transmitter must

(*Continued on page* 80)

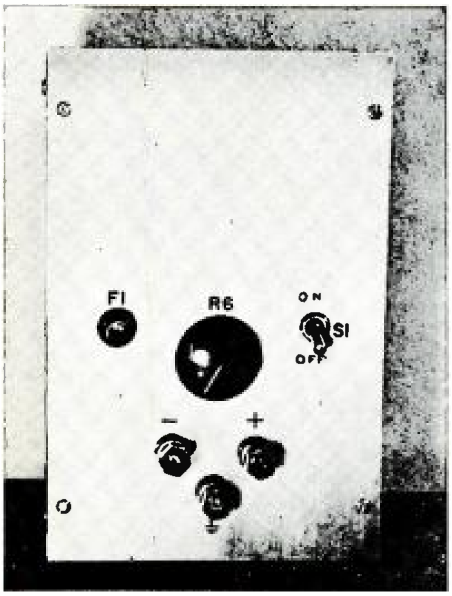
Fig. 12. One possible form of frequency-doubling circuit, for converting pilot to regenerated subcarrier without oscillator.



By ARTHUR GLASER / Polarad Electronics Corp.

REGULATED SUPPLY FOR TRANSISTOR CIRCUITS

Construction of a regulated, variable-voltage power supply that delivers from 7 to 27 v. at up to 1 amp.



Front view of author's unit. Either side of the circuit can be grounded.

A REQUIRED part of any technician's or serious experimenter's test equipment line-up should be a regulated, variable-voltage power supply. The unit to be described was designed by the author to provide a source of power for experimental transistor circuits. The output voltage can be varied between 7 and 27 volts at currents up to one ampere.

Circuit Theory

Thevenin's theorem states that any electrical network may be represented at an arbitrary pair of terminals by a constant "ideal" voltage source in series with an internal impedance. The voltage drop in this internal impedance will cause the terminal voltage to decrease with increasing load current. In order to approach an "ideal" voltage source, the internal impedance should be as low as possible.

In order to reduce the source impedance, a transistorized feedback regulator is used. The regulator consists of four parts: a sensing element, a reference source, a comparison element, and a control element. See Fig. 1.

The control element is a series pass transistor. The voltage between the emitter and base of a transistor is very small. When connected as an emitter-follower, the emitter voltage will be almost the same as the base voltage. The output impedance is very small because the emitter current is much larger than the base current. In order to increase the current gain, the control element consists of two cascaded emitter-followers (V_1 and V_2). The current gain of this combination is approximately 1000.

The sensing element is a potentiometer (R_6) connected across the output. It puts a fraction of the output voltage on one base of the difference amplifier comparison circuit (V_3 and V_4). The reference source is a zener diode (CR_1) in series with a resistor. This combination is placed across the unregulated source. The second base of the difference amplifier is connected to the zener diode as shown.

The output of the difference amplifier is proportional to the difference between the signals applied to the bases. This output voltage is applied to the control element. The entire system forms a closed loop enabling the regulator to automatically compensate for any changes which occur at any point in the loop.

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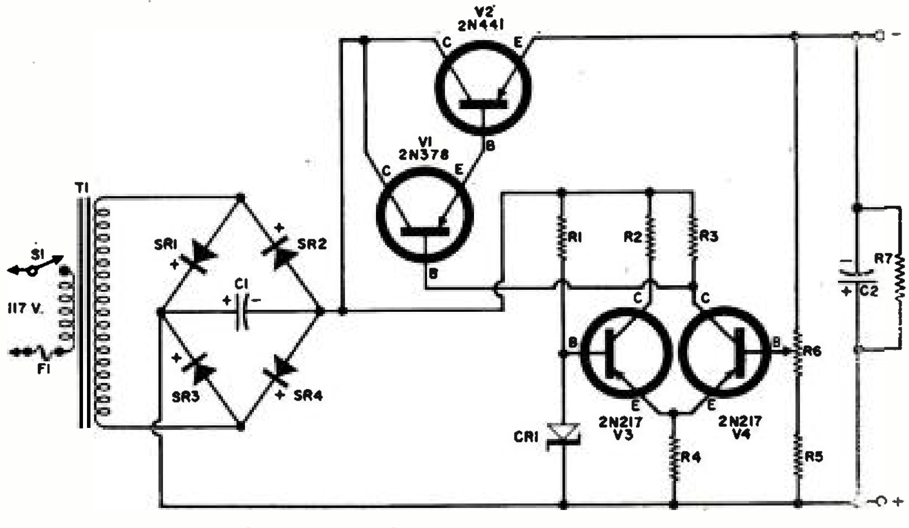
Fig. 1. Transistorized regulator is combined with a full-wave bridge circuit.



EDITOR'S NOTE: Before starting construction of this project, we suggest that the builder check on the availability and prices of the various semiconductors required in the circuit.

R_1—6800 ohm, ½ w. res.
R_2—12,000 ohm, ½ w. res.
R_3—22,000 ohm, ½ w. res.
R_4—2200 ohm, ½ w. res.
R_5—1800 ohm, ½ w. res.
R_6—5000 ohm linear taper pot
R_7—330 to 470 ohm, 5 w. res.
C_1—250 µf., 50 v. elec. capacitor
C_2—500 µf., 25 v. elec. capacitor
S_1—S.p.s.t. switch
F_1—1 amp fuse
CR_1—6.8 v., ¼ w. zener diode (Motorola Type ¼ M6.8Z5)
SR_1, SR_2, SR_3, SR_4—70 v. @ 10 amp silicon diode (Sarkes Tarzian 1N1621 used by author. Any unit providing 30 v. @ 1 amp would be suitable, see text)
T_1—Power trans. 117 v. pri., 25.2 v. @ 1 amp sec. (Stancor P-6469 or equiv.)
V_1—"p-n-p" transistor (Tung-Sol 2N378)
V_2—"p-n-p" transistor (Motorola or Delco 2N441)
V_3, V_4—"p-n-p" transistor (RCA 2N217)

MAKING THE MOST OF METER MOVEMENTS

You can adapt almost any available, basic unit to almost any use with little trouble.

By *JACK H. FARTHING*
Director, Electronics Research Laboratories

HOW MANY times do we fail to install a meter where we need one simply because none of the units on hand seems to lend itself to direct application? It may be an arrangement where we would want to monitor some particular voltage or current constantly. It could be an improvement in an existing instrument. Perhaps it is an interesting project that has been put off because the particular meter cannot be found in the junk box.

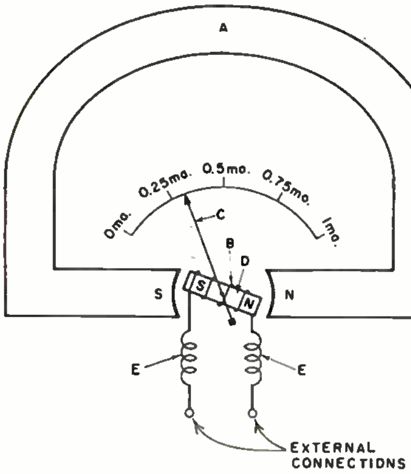


Fig. 1. The working elements, in simplified form, of a basic, moving-coil meter.

In the midst of a field as fast-moving as electronics, we become so involved with the latest complexities that we sometimes forget simple principles. Yet the few of these that apply to meter movements allow us to adapt almost any movement for any measuring purpose. To understand how, it will help if we first review fundamental operation.

The basic meter used in the majority of electronic circuits is of the moving-coil type. Construction, as shown in Fig. 1, generally consists of a permanent magnet (*A*) and a movable coil (*B*) of fine wire that actually rotates about a pivot. Attached to the coil is a pointer (*C*). A core of soft iron (*D*) is inside the coil, and a set of spiral springs (*E*) is used to return the coil and pointer to a reference or zero point.

In most cases, there are two springs, insulated from their mountings, with each connected to one end of the moving coil. Thus the springs also serve to provide a path for current through the coil. When current is applied, an electromagnetic field is developed about the coil. The polarity and intensity of the field depends on the direction of the current and its strength.

Suppose that a current of such polarity is introduced that the left end of the coil becomes a south magnetic pole. It will be repelled by the south pole of the permanent magnet but attracted by its north pole. At the same time, the right end of the coil becomes a north pole attracted to the south pole of the permanent magnet. The direction of rotation, clockwise in this case, is a function of the way in which the lines of force in the two fields are aligned with respect to each other. In practical movements, the coil is wound in such a way, not shown in the simplified illustration, that rotation is in the desired direction.

When the coil turns, it does so against the tension of the springs. If the field developed by the coil is weak compared to spring tension, the degree of rotation will be small. If current is increased, the field will be stronger and there will be correspondingly more rotation.

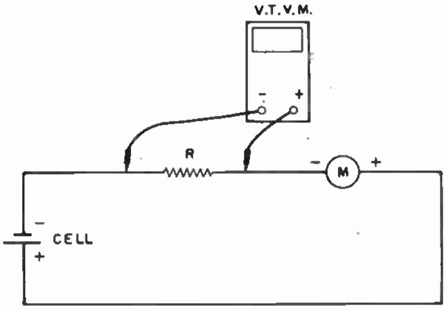
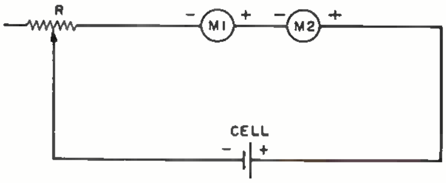


Fig. 2. Voltage reading across a known series resistor and quick calculation can be used to determine full-scale current.

Fig. 3. In another method for finding full-scale current, this value is read on another, known meter put in series.



The moving-coil meter usually has a linear-scale response. This means that, if .5 milliampere causes the pointer to deflect one inch away from the zero position, 1 ma. will cause two inches of deflection.

If you wish to adapt a basic meter to a particular purpose, you must determine two things about it: the current required for full-scale deflection and the resistance of the coil in the movement. The first characteristic is often found printed on the face of the scale in the lower left or right corner. It might, for example, read FS=100 μa., which would mean that full-scale deflection takes place when 100 microamperes flow through the meter. If no markings are found, the rating may be determined by one of the methods to be described. As a precaution against error, it may be advisable to use more than one method, checking the results against each other.

Series-Resistor Method

First remove the case from the meter (carefully!) and also remove any shunts (parallel-resistance coils), series resistors, capacitors, or other added components not essential to the basic meter movement. In this form, the instrument is most flexible, since shunts or series resistors can always be added externally to suit the particular application. In most cases, auxiliary components are bolted to the back of the case in the center of the magnet.

Some shunts will be in the form of a large wire connected directly across the meter terminals. If this is the case, the wire can be snipped with a pair of cutters and left in the meter.

Several fixed resistors are selected from whatever is on hand. Values should range from 500 ohms to 2 megohms. Tolerance should be at least 5 per-cent, with closer tolerances used if they are available. This range should cover practically all meters. Some fresh flashlight cells are also needed as a current source.

Start with the highest-value resistor (*R*) and a single cell placed in series with the meter, as shown in Fig. 2. If the meter terminals are marked as to polarity, be sure to connect accordingly. If there are no markings, tap the lead to one of the terminals momentarily and watch the pointer. If the latter is deflected off scale in the wrong direction, to the left, reverse connections to the battery or the meter. If the pointer goes off scale to the right, disconnect the battery at once and increase the value of the resistor (double it, at least); then work down until a resistor is found that will cause the pointer to rest somewhere within the center third of the scale. If the pointer is not exactly over one of the calibration markings, try to find a resistor, close in value to the one last used, that will produce a reading exactly on some mark of the scale. This will simply make calculation easier.

Note the mark and determine its fraction of full scale. In other words, if there are 100 divisions on the scale and the pointer is resting on the twentieth, the fraction would be 20/100, or ⅕ of full-scale reading. Leave the meter connected and use a v.t.v.m., as shown in Fig. 2, to measure the voltage drop across the resistor. Since this drop will be small in most cases, take care to zero the v.t.v.m. properly and use the lowest available voltage scale that will give a substantial reading to insure accurate measurement.

Since the current is the same in all parts of a series circuit, we can determine meter current if we know its value through the resistor. This can be derived from Ohm's Law ($I=E/R$), using the voltage reading for E and the known value of resistor R. If the v.t.v.m. reading was .75 volt and the resistor value is 750 ohms, then .75/750 = .001 ampere or 1 ma. This amount of current has deflected the meter pointer through ⅕ of full scale. Since deflection in a moving-coil meter is linear, full-scale deflection would require 5 times as much current, or 5 ma. For those who want a handy formula, $I_f = D_f I_m / D_m$, where I_f is the current required for full-scale deflection, D_f is the number of calibration markings in the full scale, I_m is the current through the meter during the test, and D_m is the number of scale marks to which the pointer deflects during the test.

Second-Meter Method

Another technique, which is simpler, requires an additional current meter that is known to be correct. This can be nothing more than a multi-range v.o.m. The unknown instrument (M_1), the known meter, and a variable resistor (R) of high value are placed in series across a battery, as shown in Fig. 3, with R set for maximum circuit resistance. The resistor is then adjusted to produce usable deflection on both meters. The percentage of deflection on unknown meter M_1 is noted, as is the actual current reading on known meter M_2.

For example, suppose that M_2, with a full-scale reading of 20 ma., shows half-scale deflection, or 10 ma. This is the current flowing through both meters. If M_1 reads 20 divisions out of a total of 100, its full-scale reading would be 50 ma. The mathematical expression for this relationship is exactly the same as the one given in the first method described.

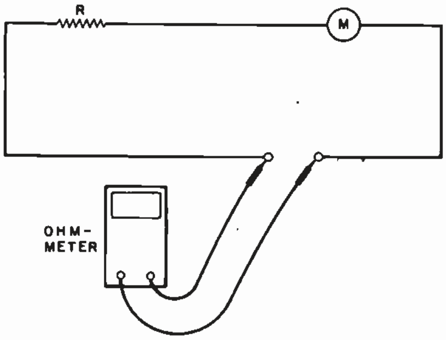


Fig. 4. An ohmmeter can be used to determine internal (coil) resistance with accuracy and no risk of movement damage.

Another method, when available information makes it possible, relies on a simple calculation alone, without measurement. On some meters, you will find an ohms-per-volt rating marked somewhere on the face. It may read something like "2000 ohms/volt" or "10,000 ohms/volt." If the scale is marked in volts, you can determine easily what total resistance is required in the meter circuit to produce full-scale reading.

Suppose that, on a 2000 ohms/volt unit, the maximum scale reading is 50 volts. Multiplying these figures reveals that 100,000 ohms is present on this scale. (This product is not necessarily the resistance of the coil in the meter movement itself; it simply establishes total resistance needed on this scale, which can be made up partly of added, fixed resistors. Nevertheless, it establishes a meaningful relationship that depends on the meter's characteristics.)

If 50 volts are needed to deflect full scale across 100,000 ohms, we can determine the current needed to produce this reading through the meter, with or without series resistors, from Ohm's Law: if $I = E/R$, then 50/100,000 = .0005 ampere, or 500 microamperes.

Checking Coil Resistance

To get the most out of a basic movement you have to know its internal resistance, or coil resistance, in addition to full-scale current. Many textbooks will tell you flatly *never* to make this measurement with an ohmmeter. There are two good reasons for this warning. In the first place, the ohmmeter battery might send enough current through the coil to cause damage. Even if it doesn't, normal ohmmeter inaccuracy may falsify the reading sufficiently so that the latter is inadequate for use. In spite of the textbook injunction, you can realize both safety and acceptable accuracy with an ohmmeter—by observing a simple procedure.

As in an earlier method, all that is needed is an assortment of resistor values and they do not have to be precise. Start with the highest value in series with the movement and the ohmmeter, as shown in Fig. 4. The resistor must be large enough to prevent meter overload. About 1 megohm should do. Reduce R until the pointer deflects toward the center of full scale. If the pointer shows a tendency to move to the left, reverse leads.

With some deflection obtained as noted on the unknown meter (the exact reading does not have to be noted), observe the ohmmeter reading. Let us say that the latter is 3200 ohms. You also notice that the marked value of the resistor is 3000 ohms. Do *not* assume that the resistance of the meter movement alone is 200 ohms. Inaccuracy in the ohmmeter and tolerance variation in the resistor can combine to throw you off quite a bit.

Instead, connect the ohmmeter across the resistor alone. Suppose you read 3100 ohms. The difference, 100 ohms, is meter resistance. Ohmmeter error does not make much difference here, as it is likely to be the same on both readings, which will be made on the same range and the same portion of the scale. To be more certain, take readings using one or more other resistors different in value from the first but not too far from it. If

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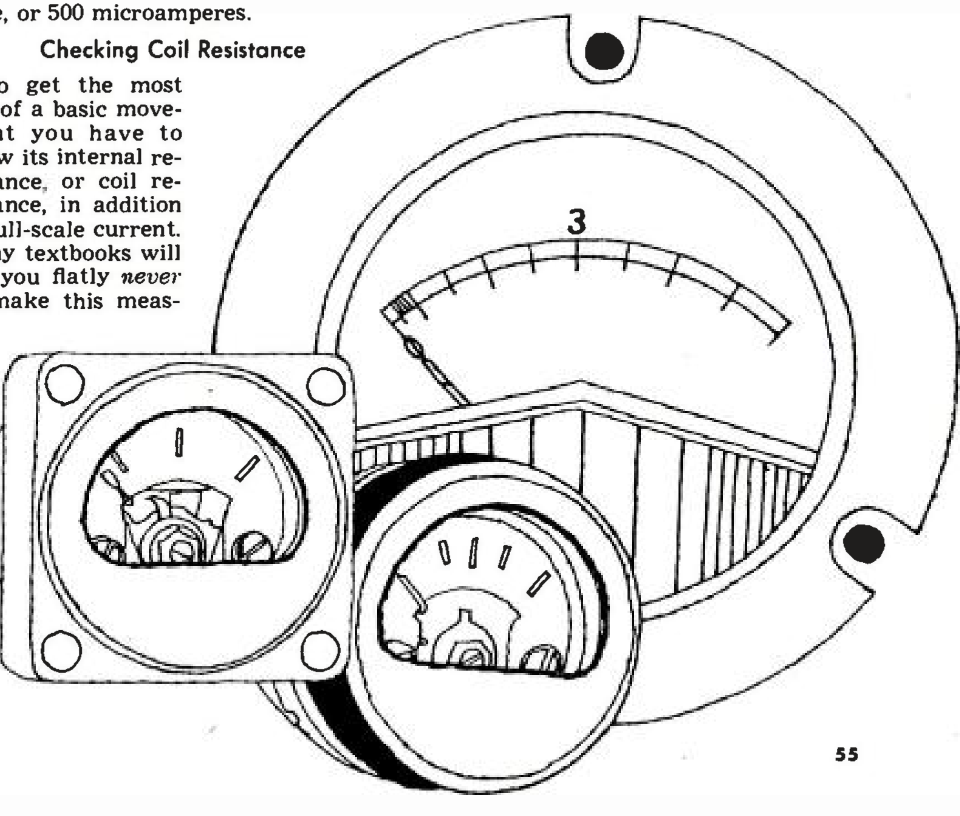
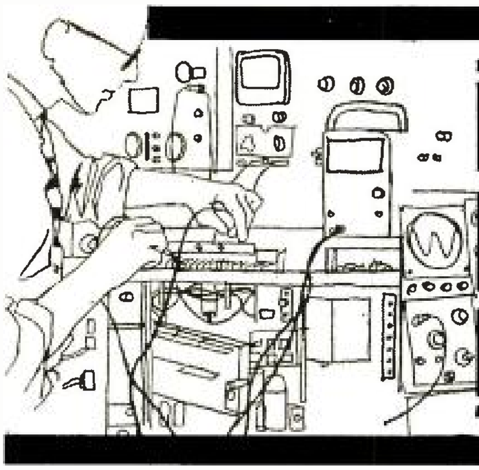




MAC'S ELECTRONICS SERVICE

SOMETHING NEW

BARNEY had just returned from a service call. He parked the truck and joined Mac, his employer, who was standing outside the service shop bareheaded in the cold January air gazing up at a brand new sign hanging over the entrance to the shop.

" 'Mac's Electronics Service,' " Barney read aloud. "That looks real cool, boss. When did the sign men put it up?"

"They just left," Mac answered as he took one more admiring glance at the new sign glistening in the late afternoon sun; "but your choice of adjectives reminds me we're both probably catching pneumonia. Let's go inside."

"It seems sort of appropriate for us to be starting the new year with a new sign." Mac commented as Barney shrugged his way out of his heavy coat. "I just hope we're making a wise move in taking on industrial electronic servicing in addition to our radio and TV work."

"Well," Barney said, "if all the industrial jobs are as interesting and as easy as the one I was just on, I think I'm going to like it. Come on back to the bench. I want to show you how a smart joker can put to use something most people consider a nuisance."

Mac watched as his assistant plugged a microphone into the input of the signal tracer and advanced the gain control until a feedback howl just started. Next Barney picked up a heavy sheet of corrugated cardboard from a shipping carton and inserted it between the microphone and the speaker of the signal tracer. The howl stoped. Barney removed the cardboard. The ringing sound returned.

"Now that phenomenon is something anyone who has anything to do with p.a. work has experienced many times," Barney explained importantly. "Any time the gain of the amplifier between the microphone and the speaker furnishes more amplification than is lost in the air path between the speaker and the microphone, we have a feedback howl. We try to stop it by increasing the 'resistance' of this path, say by moving the mike farther from the speaker, by aiming the speakers away from the mike, by using a directional mike that has little response in the direction of the speaker, by enclosing the mike in a sound-proof booth, etc. Or we can reduce the amplifier gain until it doesn't exceed the losses present in the acoustic path."

"Given time, I might have figured that out by myself," Mac commented dryly.

"So OK," Barney said with a reddening face; "sometimes I get carried away when I start explaining something—especially if I'm half explaining it to myself. Anyway, we could make a counting device out of this crude arrangement right here. Suppose sheets of cardboard were carried along on an endless belt so that they passed between the mike and the speaker. Every time a sheet of cardboard moved between these two, the howl would stop. Now if we had a diode rectifying the audio signal present when the system was oscillating, and if this diode furnished bias to a tube so that its plate current went up every time the oscillation started but fell back when no oscillation was present, the plate current of that tube could operate a relay or an electric counter; right?"

"Sounds logical," Mac admitted cautiously.

"There are quite a few things wrong with this crude system," Barney confessed. "For one thing, that howling would drive you nuts. A system such as this always oscillates at the frequency that provides the greatest ratio of amplifier gain to acoustic resistance—in other words, the frequency at which it is easiest to maintain the oscillation. With audio equipment, naturally, this falls in the audio range, usually near the lower to middle range; for sound attenuation increases as the square of the frequency, and most amplifiers have maximum gain in this region. Another objection would be that any loud sound could trip the relay, even if the presence of a cardboard sheet in the sensing path would be holding the relay open.

"But suppose we replace the mike and the speaker with two magnetostrictive 'sensor' units constructed to respond only to frequencies 50 cycles either side of a center frequency of about 38,000 cycles-per-second. Let's use transistors instead of tubes in the amplifier to provide long life, low maintenance, and freedom from microphonic response in the amplifier itself, for we are going to build a gain of 10,000,000 times into this amplifier.

"Raising the frequency to 38,000 cycles takes it far outside the range of human hearing. That, plus restricting the frequency response of the sensor unit, greatly reduces the chance of response to any extraneous 'sound.' What's more, the ultrasonic waves are very directional, making it easier to confine them to a desired path.

"Well, that's exactly the kind of counting device the relay factory called on us to service. These 'Sonac' ultrasonic control systems for solids and liquids are a product of the *Delavan Manufacturing Company* of West Des Moines, Iowa. Very fortunately you had secured a Technical Information Handbook on these controls from the manufacturer for our files when we took on the industrial electronic service for the relay factory, and I took care to bone up on this very thoroughly before I made the call."

"What was the trouble?"

"The installation is used to count relays moving along on a belt. The relays interrupt the ultrasonic beam as they pass between the two sensor units, and the relay actuated by the transistorized amplifier operates a counter. The system had worked perfectly since it was installed several months ago until just recently. In the past few days, though, it started counting erratically. In each case it gave a higher count than it should have.

"The first thing I did was check everything thoroughly. I could not find a thing wrong. The sensitivity control, which is actually the gain control of the amplifier, was properly set; the relay contacts were clean; there were no loose connections between the sensor units and the amplifier. The unit counted perfectly every time the beam was interrupted, even when I deliberately moved the sensor units much farther apart; and it did not count when the beam was kept cut off."

"OK. quit trying to build up suspense," Mac ordered. "What did you find wrong?"

"My first clue came when I noticed an air drill lying on the floor next to the relay belt and some freshly-drilled holes in the cement floor. I was told they were preparing to install some new machinery at that spot. I had a man operate the drill while I watched the counter. Sure enough, with the ultrasonic beam blocked off, the counter flipped up erratically when the drill was chattering away."

"How come?"

"The Technical Manual explains that for any kind of an external device to interfere with 'Sonac,' that device must produce a large volume of ultrasonic sound at exactly the right frequency, and this has to reach the receiving sensor in amounts comparable to the sound received from the transmitting sensor. Most noise-producing devices, while they may shatter your eardrums

(*Continued on page 82*)

the direct-writing oscillograph

One of industry's most important instruments is discussed in detail. The technician is told just what the oscillograph will do and how it is utilized.

By RAY A. SHIVER
Instrumentation Laboratory
AiResearch Mfg. Co.

IF one were asked to pick the single most widely employed measuring instrument in daily use throughout the electronics industry, the D'Arsonval meter would probably suggest itself to many. This comparatively simple instrument is the basis for most oscillograph recorders. By substituting a writing stylus of some sort for the familiar pointer attached to the moving coil, we have an instrument capable of producing marks or "traces" corresponding to current flow through the coil. If we now add a roll of paper to record the traces produced by the stylus, we have a simplified version of a direct-writing oscillograph. This type of recording instrument is a basic tool in instrumentation systems and can be found in daily use in industrial instrumentation, medicine, and military applications. It is capable of producing a rapid and accurate record of any type of information that can be expressed as a d.c. function.

The Galvanometer

Oscillograph recorders are characterized by the use of the galvanometer as a writing instrument, whether they be of the direct-writing type or utilize the photographic system. Fig. 1 shows a typical galvanometer used in a direct-writing system. Note the large coil and permanent magnet assembly. This type of construction is necessary to provide sufficient torque to deflect the writing stylus over the recording paper at a constant pressure. The coil in this type of galvanometer is very highly damped, *i.e.*, rigidly suspended, to insure good writing characteristics throughout the frequency range of the instrument.

The frequency range for this type of system is limited from d.c. to around 100 cps since the galvanometer coil is required to move a sizable mass in the writing stylus while maintaining uniform pressure, and the writing speed of the stylus cannot be extended beyond this point without loss of definition. Since a galvanometer of this type is inherently a low-impedance device, the electronic driver unit is required to furnish a proper match to the coil and a considerable amount of driving power for proper operation. Beam-power tubes or power transistors are commonly used as balanced d.c. amplifiers to furnish the required driving power.

The Writing Systems

Fig. 2 shows the first writing system developed for the direct-writing oscillograph. This merely consisted of hanging a stylus on the end of the galvanometer pointer. While this presents no problem in a D'Arsonval meter, since the scale can simply be ruled along an arc corresponding to the arc the pointer is required to travel, it does present some interesting problems when we attempt to apply the same method to record on moving paper. If we are to have a system for making accurate time and amplitude measurements, it is necessary to rule the recording paper with some sort of reference lines. A sample of paper designed to be compatible with the system of Fig. 2 would have to be ruled as shown in Fig. 3A. As may be suspected, this would be exceedingly difficult to work with and further refinements are necessary. These mainly consist of lengthening the writing stylus to produce a correspondingly smaller arc at the point of contact with the paper and limiting the stylus travel to a very small part of that arc. This allows the recording paper to be ruled as shown in Fig. 3B. This is known as the *curvilinear* writing method and is one of the two types available in direct-writing oscillographs today. Fig. 5 shows the *rectilinear* writing method. This system permits the recording paper to be ruled in straight lines of equal separation and is the preferred system.

The arc produced by deflection of the recording stylus is compensated for in several ways in order to produce a linear writing system. First, the recording paper is drawn across a knife edge at the point of contact with a heating element located at the tip of the stylus. Note that the heating element consists of a rather long strip of resistance material which contacts the paper at different points as it moves across the surface. This has the effect of a variable-length stylus that becomes longer as it travels away from the center of the paper.

Second, the stylus is made as long as practical in order to make the arc at the end of the pen as small as possible. Finally, the distance the pen is required to travel is kept to a minimum, being on the order or five centimeters or about two inches for each channel of data.

Three basic types of writing styli are available for this type of oscillograph. They are the inked pen, the heated stylus, and the high-voltage type. The inked-pen system requires the least amount of stylus pressure and is capable of very fast writing speeds but is subject to the evils of all ink-writing systems, including excessive flow and clogging difficulties and the tendency to spatter at fast writing speeds.

The heated-stylus is the most popular for instrumentation purposes because it is a relatively simple and foolproof method of recording on paper. The recording paper for this type of system is coated with a special heat-sensitive plastic material that exhibits a clean, sharp trace when exposed to the proper stylus temperature. Although not capable of the high writing speeds of the inked-pen system, due to the greater stylus pressure required, this system is readily adaptable to *rectilinear* recording and has the added advantage of being practically maintenance-free.

The high-voltage system utilizes a high-potential stylus that burns through a special sensitized paper to an anode platen underneath. This system is also applicable to *rectilinear* recording and is used where a faster writing speed is desired than can be obtained with the heated-stylus method. It has the disadvantage of a build-up of carbon deposits, due to the burning process, which must be removed periodically.

Paper Transport Assembly

Since time-base accuracy is very important for the faithful reproduction of the recorded signal, the paper transport system must be as perfect as possible. This is achieved through the use of precision gears for the various paper speeds and a highly stable synchronous motor-drive system. Paper speeds are selected by a lever which provides the proper gear ratio for the range required or, on some models, by individual push-buttons for each range. Speed selections range from .1 millimeter a second up to 250 millimeters a second. The recording paper is ruled in one-millimeter squares throughout each roll and it is only necessary to know the paper speed to arrive at an accurate time base. An example of this will be found in the section dealing with a sample recording. In addition to the standard galvanometers, an auxiliary stylus is provided which records on the edge of the paper any special event or timing application that may be desired.

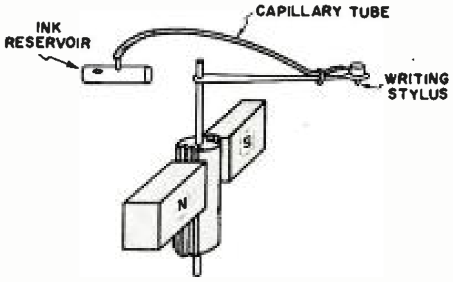


Fig. 2. The first writing system developed.

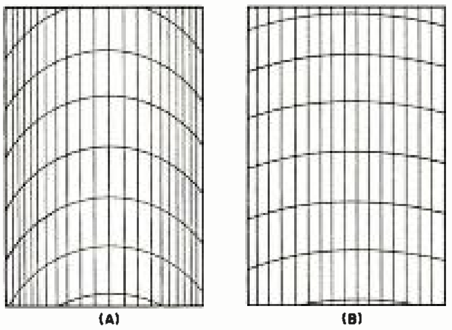


Fig. 3. (A) Graph suitable for use with the writing system in Fig. 2. (B) By using a longer writing stylus, the recording paper may be ruled as shown. This type of recording is in present use and is called curvilinear.

The Electronics System

Fig. 6 is a photograph of a complete direct-writing system. This particular instrument is an *Offner* "Dynagraph" and contains some of the newest features available in this type of recorder, including an all-transistorized electronics section. The lower portion of the unit contains the paper transport and drive assembly and visible in the top half are the various plug-in preamplifier and driver units that make up the electronics section.

A typical plug-in electronic unit is shown in Fig. 4. Note the compact transistorized construction. Preamps are available in various circuit configurations to meet almost any recording application. Since this type of oscillograph is primarily a d.c. instrument, a.c. signals have to first be converted to corresponding d.c. voltages in order to drive the galvanometers. This will allow the recording of medium- and high-frequency information with limitations; that is, the rate of change of such information must not exceed the time response limitations of the galvanometers. The a.c. signals, depending on requirements, can be converted to d.c. through the use of external equipment or may be fed directly to the recorder when the proper type of preamp unit is used.

A Typical Recording Problem

Fig. 7 is the block diagram of a recording setup that would be applicable to the direct-writing recorder. In this example it is desired to test the performance of an air-turbine-driven alternator system by recording and observing the functions shown on the block diagram. Plug-in preamplifier units and transducers needed include the following: For recording the air-turbine inlet temperature we would first require an appropriate thermocouple for the temperature range to be recorded. For this particular range (0-500 degrees Fahrenheit) an iron-constantan type of thermocouple would be used. Since a thermocouple is a junction of two dissimilar metals that produces a very small d.c. voltage that varies directly with temperature change, a stable high-gain d.c. preamp would be required for this application. A chopper-input d.c. unit would meet these requirements.

This type of circuit contains a chopper unit which is similar to a vibrator found in an automobile radio except the chopper contacts are rated at only a

Fig. 4. Plug-in electronic unit used in direct-writing system. ➧

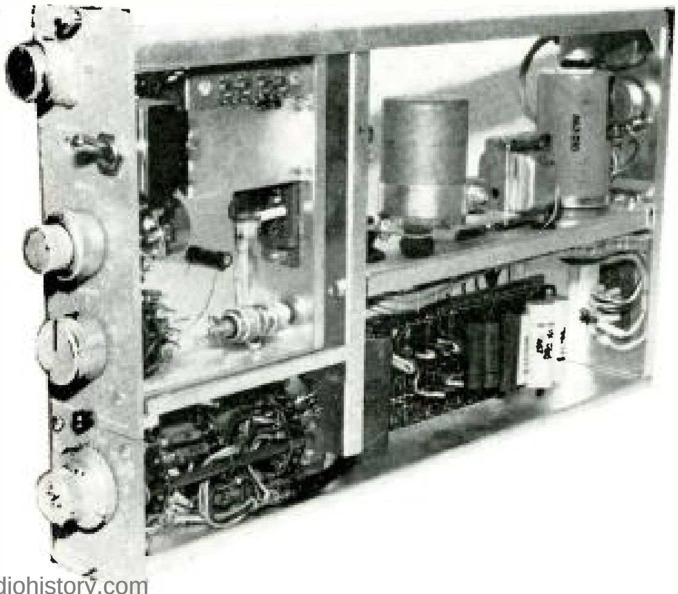
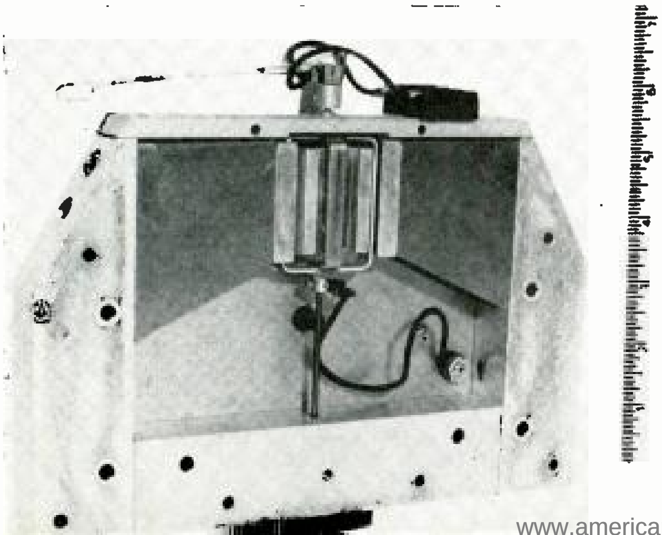


Fig. 1. A typical galvanometer used in a direct-writing system.



few milliamperes d.c. and the rate of operation is usually 60 or 400 cps. A low-level d.c. signal fed into the chopper is converted to a corresponding a.c. signal, amplified through a conventional a.c. amplifier, and then rectified to produce a high-level d.c. signal corresponding to the low-level input signal. This type of circuit eliminates the drift problem usually associated with conventional balanced d.c. direct-coupled amplifiers.

To provide a d.c. signal that indicates air-turbine inlet pressure, we shall use a strain-gage pressure transducer along with a bridge-type strain-gage preamplifier unit. This plug-in unit provides excitation voltage for the strain-gage bridge circuit of the pressure transducer and also contains controls for the balance, calibrate, and output-level functions. Included in the preamp is a chopper d.c. amplifier for low-drift d.c. amplification.

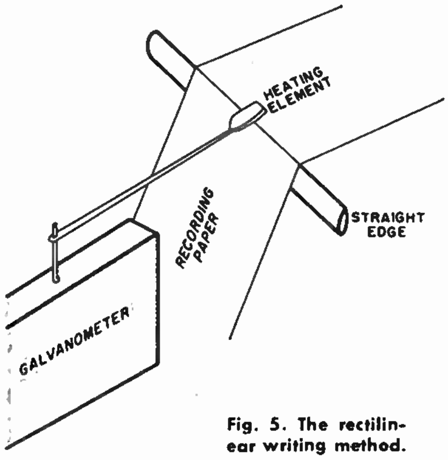


Fig. 5. The rectilinear writing method.

Fig. 6. A complete direct-writing system employing all-transistorized circuitry.

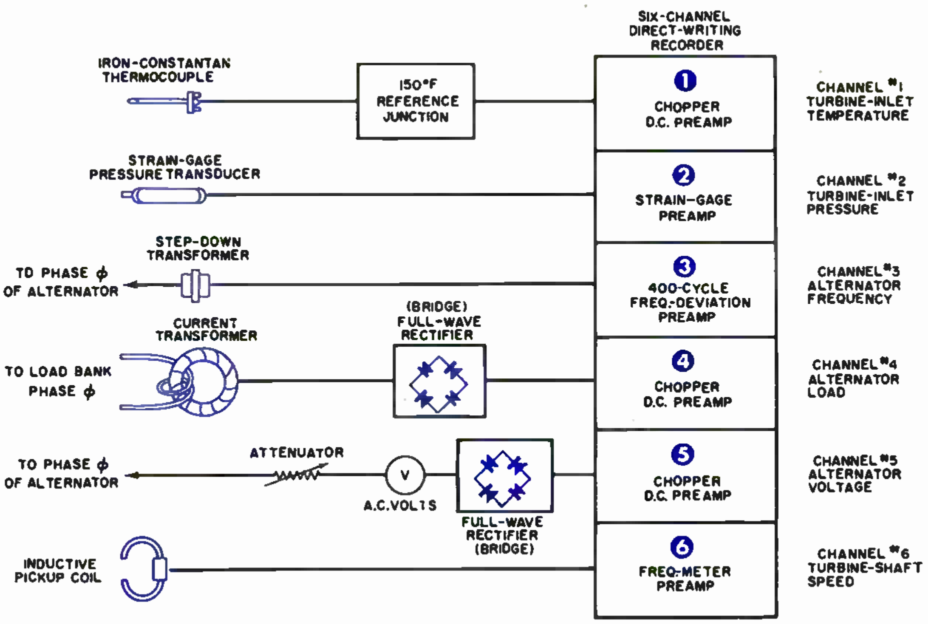


Fig. 7. Block diagram of a recording setup employed with a direct-writing recorder.

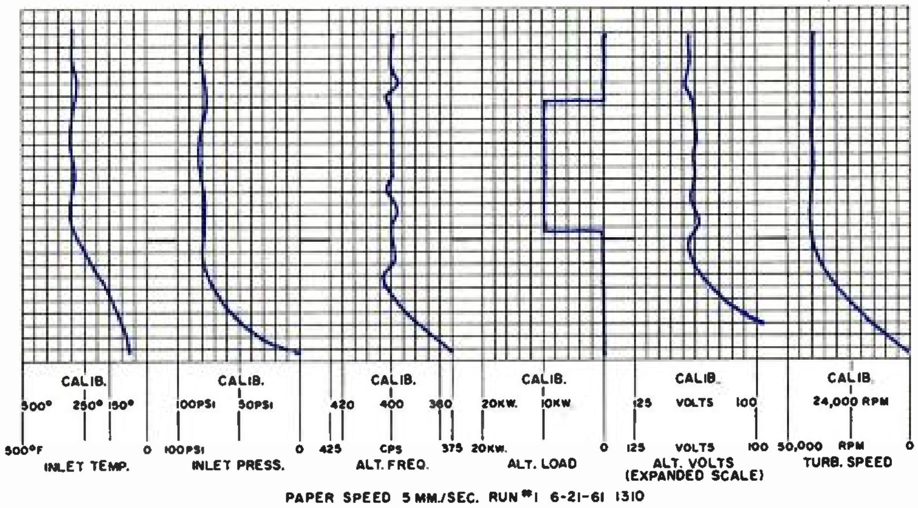


Fig. 8. A somewhat simplified copy of the record made by the oscillograph. All the information shown may be lettered directly on the instrument's graph paper.

To record the alternator frequency of the unit under test we require a sample of one phase of the voltage generated by the alternator. This can be accomplished by connecting a small step-down transformer at the appropriate point on the alternator to provide a few volts of signal to the recorder.

To measure small frequency changes in the alternator voltage we require a preamplifier unit that is not sensitive to voltage variations but will indicate any change in frequency within a narrow passband. A frequency deviation unit would meet these requirements. This type of circuit includes sufficient limiting stages to minimize amplitude variations and a discriminator-type circuit designed for a particular center frequency, in this example 400 cycles. Any variation from the center frequency will produce a corresponding negative or positive output voltage. Included is a precision 400-cycle tuning fork to provide a calibration point for adjusting the discriminator for zero output at exactly 400 cps.

Since the output of the alternator is to be fed to a resistive-type load bank in order to check the unit under actual loaded conditions, we shall need a method of recording the various load points as they are applied to the alternator. To accomplish this we install a current transformer in one phase of the alternator load-bank circuit, as shown in Fig. 7. This will provide an a.c. voltage proportionate to the amount of power consumed by the load bank from one phase of the alternator output. The signal is then rectified and applied to the appropriate d.c. preamplifier.

Alternator voltage can be obtained by sampling one phase of the alternator output. After rectification we have a d.c. analogue signal that varies directly with any changes in alternator voltage. This channel of data requires some special circuitry in order to obtain an expanded voltage scale and will be covered in detail in the next section.

An electronic tachometer or frequency-meter preamp is the type chosen to record turbine shaft speed. This plug-in unit is similar to most electronic tach-

(*Continued on page* 76)

A.C. METER CALIBRATION

By **TOM JASKI**

Precise a.c. voltages for checking are hard to come by, but you can manage with standard d.c. voltages, plus a few resistors—and an inexpensive thermometer.

CALIBRATION of the d.c. scales of a voltmeter need not be too difficult, because reasonably accurate standards of one form or another are generally available. (See "Calibration Standards for the V.O.M.," October 1961.) However, precision on a.c. is something else again. With precise a.c. voltage standards harder to come by, it seems that one would have to settle for less accuracy.

Another obstacle is the fact that a.c. scales, unlike d.c. scales, are not linear; and the pattern of nonlinearity is not necessarily identical on all scales. This means that a greater number of known a.c. voltage check-points are needed. Where to get these voltages?

Here is a method in which the a.c. reference voltages used do not have to be known in advance with great precision. It has only two limitations: your patience and the accuracy of the d.c. scales on the instrument. If you have checked the latter carefully (refer to the article mentioned earlier) or otherwise know them to be close enough for your purposes, the only other important piece of equipment needed is a good thermometer.

The author used one that reads in the range of 100° F, although this requirement is flexible. A fever thermometer is too inconvenient, as it has to be shaken down to note changes in readings. It does not have to be a precision instrument in itself, since comparative rather than absolute readings are important; that is, the thermometer need only be able to repeat the same reading for the same temperature, whether accurate or not. An inexpensive device of the type that has a glass, etched-stem scale will serve the purpose. Along with it, you will need some wire-wound power resistors, and they do not have to be precise either.

The method owes its feasibility to two facts. One is Joule's Law, which states that the heating in a wire is directly proportional to I^2R, or the power drop in the wire. The other fact is our definition of the "effective" or r.m.s. value of an alternating current or voltage. We define this as being the same as the d.c. value that produces the same heating.

Now suppose you start with a wire-wound resistor whose value is about 30 ohms. You want to check your voltmeter's accuracy at some relatively low value, say near 3 volts. You have a 6.3-volt filament transformer that is center-tapped, which gives you an a.c. source of approximately 3.15 volts. It doesn't have to be exact. Connect the resistor between one side of the filament winding and the center tap. Insert the thermometer in the resistor body, wrapping the bulb end of the former in aluminum foil so that it makes good thermal contact with the resistor. With the equipment so arranged (Fig. 1), turn on the power to the transformer.

This first step will take some time, in fact several minutes, until the temperature of the resistor stabilizes and the reading on the thermometer stabilizes. This is where the patience comes in, but there is another activity that will fill part of this time. To be sure that you can duplicate this situation accurately later on, you should not only take a reading of the a.c. voltage from the transformer secondary across the resistor, but also of the a.c. voltage in the transformer primary. Your uncalibrated voltmeter is good enough for this purpose. Once more, we are concerned with repeatability rather than absolute accuracy. The purpose in noting the primary voltage, which is that of the a.c. line. is to guard against being thrown off by any change in line voltage that may occur in the middle of the experiment. Your uncalibrated meter is good enough to note a *change* in reading.

When you are sure that the thermometer reading has settled down (with the values given, it should be in the vicinity of 100° F), stick a bit of tape on the thermometer's scale at the exact point it reads, or otherwise mark this point accurately. You are now ready for the second step.

Fig. 1. First step: "taking the temperature" of a resistor across an a.c. source.

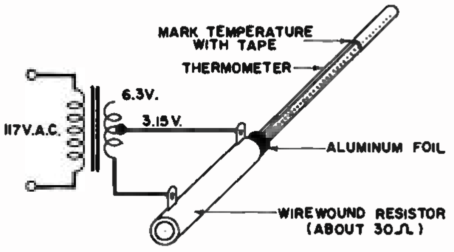
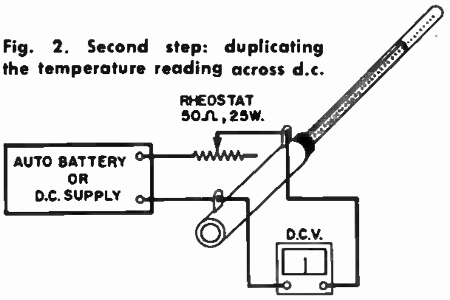


Fig. 2. Second step: duplicating the temperature reading across d.c.



Remove the transformer connections from the resistor and connect the latter across a heavy-duty d.c. source, such as an auto battery. A. d.c. supply will do provided it is reasonably stable and can supply high current. The connection should be made through a rheostat, as shown in Fig. 2. so that you can adjust current and voltage across the resistor, if there is no control in the d.c. source you are using. In this specific example, a 50-ohm, 25-watt rheostat will do.

Tentatively adjust the d.c. voltage across the resistor, using your d.c. meter scales, to the same value of a.c. voltage that you read in the first step. At worst, this will give you a fairly close starting point. Now watch the thermometer and note its reading when it stabilizes. Unless you are very lucky, it will not read exactly the same as the point marked off in the first step. You now attempt to adjust the control until you obtain exactly the same temperature reading that was marked on the thermometer. If you overshoot, for example—that is, if you get a higher reading—you will have to wait for the resistor to cool down. This procedure may take some time. However, with several tries and several readings, you should be able to read with great accuracy. When the temperature reading is exactly the same with the d.c. voltage applied as it was with the a.c. voltage applied, use the accurately calibrated d.c. scales of your meter to read the voltage across the resistor. This value must now be the same as the a.c. value across the resistor in step 1. Compare it with the actual reading you noted across the resistor on your a.c. scales earlier. The difference between these two readings is the calibration error at this particular voltage check-point.

To obtain other check-points, you will have to manipulate various combinations of voltage and resistance. A variable-voltage transformer is a good a.c. source, or you can make up resistive dividers across a fixed source. A heavy-duty, variable, d.c. supply is also helpful. If your thermometer has a limited range, you may have to use a little arithmetic and Ohm's Law to help in choosing resistor values.

For example, the source of approximately 3 volts in the illustration will send about 100 milliamperes through the 30-ohm resistor used, resulting in an approximate power drop of .3 watt

(*Continued on page* 107)

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UNIVERSAL CONTROL CIRCUIT

By **RYDER WILSON**

Construction of simple, high-sensitivity transistorized d.c. amplifier with variety of applications ranging from a phonograph amplifier to a photoelectric relay.

FROM photoelectric relay to phono amplifier, the applications of this electronic "do-all" are limited only by the user's imagination. Powered by two "C" cells and requiring a handful of inexpensive components, this "universal" control circuit can operate d.c. motors, relays, pilot lamps, meters, servos, and remote-control escapements from a variety of pickups including photocells, thermistors, microphones, and crystal phono pickups.

The circuit is so sensitive that a #49 pilot lamp in the output can be brought to full brilliance by an input of 7 microamps. A 3-μa. input is all that is required to operate a 200-ohm, 15-ma. relay. A 4" x 6" speaker can be driven to a comfortable listening level from a crystal pickup, with no preamplification.

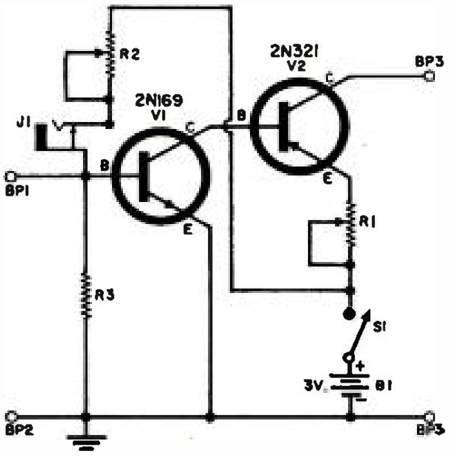
Circuit Description

The basic circuit, shown in Fig. 1, is a complementary cascaded d.c. amplifier, modified to provide extremely high current gain with a very low quiescent current. In addition, a variable output control has been included to provide clamping of the output current at any value from 2 ma. to 100 ma. As the resistance of R_1 is increased, degenerative feedback in the emitter circuit of V_2 increases, limiting the current in the collector circuit. This feature gives variable overload protection as required by meters or relays in the output.

The 2N169 and 2N321 were specially selected from the many available types for their high current gains and low leakage currents, and substitution of other types is not recommended. With the base circuit open, quiescent current should be less than 2 ma. Average current gain is about 7500, depending on the individual transistors that are utilized.

Construction

The completed unit, shown in Fig. 2, is housed in a 3" x 4" x 5" metal utility box, finished off with decals and clear plastic spray. The entire circuit could easily be contained in one-quarter the volume shown by using miniature pots and connectors and by substituting small penlite batteries for the "C" cells.



R_1—1000 ohm, ½ w. linear taper pot
R_2—1 megohm, ½ w. linear taper pot
R_3—100,000 ohm, ½ w. res.
J_1—Subminiature closed-circuit jack
BP_1, BP_2, BP_3, BP_4—Binding post
B_1—Two 1.5-volt "C" cells
S_1—S.p.s.t. switch
V_1—"n-p-n" transistor (G-E 2N169)
V_2—"p-n-p" transistor (G-E 2N321)
1—3" x 4" x 5" metal utility box (Bud CU-728, see text)

Fig. 1. Circuit of universal control amplifier.

In the photograph, the binding posts used for input and output terminals are seen on top, with the control knobs on the front face. Between the input terminals is a subminiature jack, J_1, which permits bias current to flow into the base of V_1 when the jack is not in use. A cadmium sulphide photocell or thermistor, plugged into this jack, will be in series with the sensitivity control R_2 and the base of V_1.

Fig. 3 is a photograph of the interior showing the layout of components. The two transistors can be seen at the top of the picture, mounted in clips on a 2¼"x 1¾" aluminum subchassis. The two batteries may be seen at the bottom of the photo, mounted in a double battery holder.

The 2N321 should have a layer of tape wrapped around its shell before mounting, to prevent shorting as the base is internally connected to the shell. The sensitivity and output controls, R_2 and R_1 to the right in Fig. 3, are wired to be clockwise-decreasing, with maximum resistance at the zero setting on the dial.

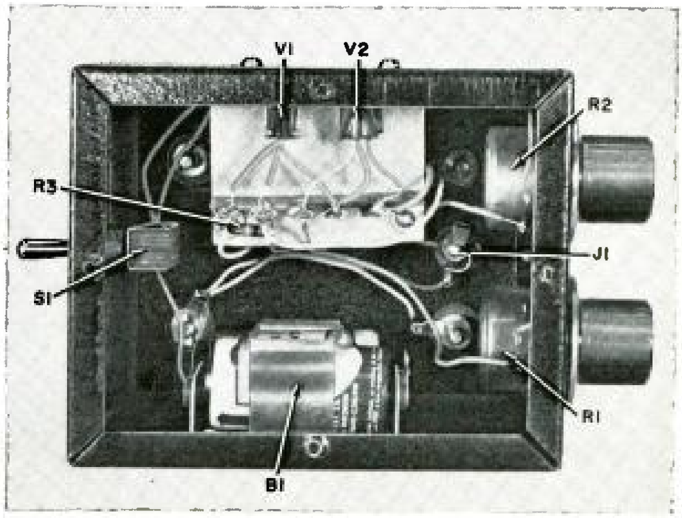
Testing the Circuit

To test the circuit, connect a 0 to 100 ma. meter to the output terminals BP_3 and BP_4. Plug a low-range microammeter into jack J_1. Set R_2 at maximum and R_1 at minimum resistance. Turn the unit on and read an input current of about 2 μa. on the meter. The corresponding output current should be approximately 13 ma. Decrease R_2 until the input current is 5 μa. and note the position of R_2. This is the proper bias setting for R_2 when the circuit is to be used as an audio amplifier or in other voltage-driving applications.

Decrease R_2 further until the output

◀ Fig. 2. Completed unit showing location of controls and terminals.

Fig. 3. Interior view shows the simplicity of the construction.



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For CCTV there are: Port-A-Studios (portable studio consoles capable of originating complete TV channels); Film Chains (to convert 16mm film into video or RF signals); manual and remote controlled transistor TV cameras; direct-view or projection monitors; video distribution equipment for flexibility and ease of operation.

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CATV

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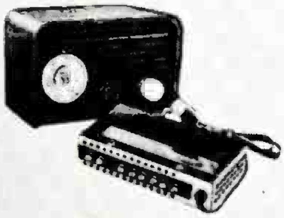

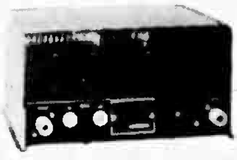

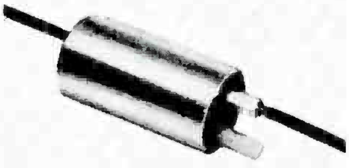

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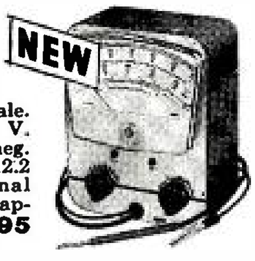

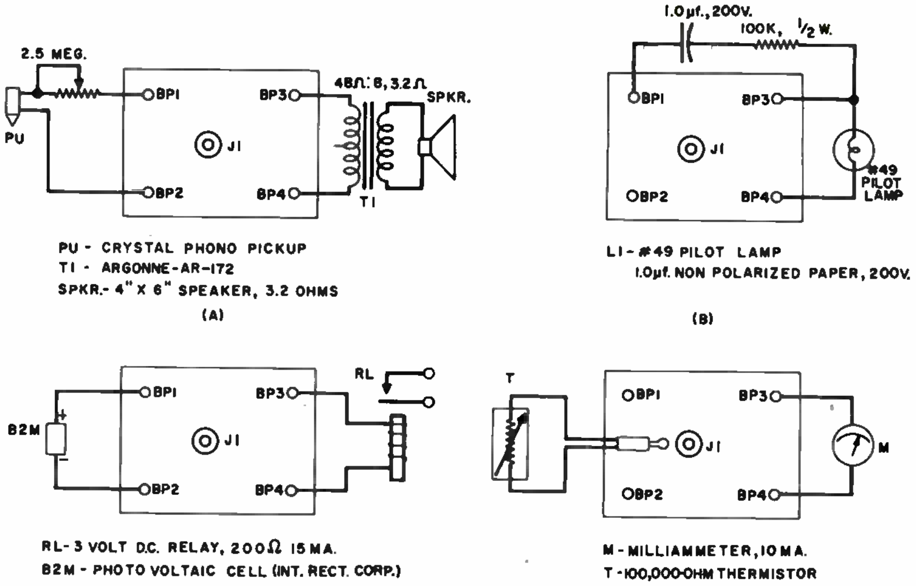

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L1 - #49 PILOT LAMP
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(B)

RL - 3 VOLT D.C. RELAY, 200Ω 15 MA.
B2M - PHOTO VOLTAIC CELL (INT. RECT. CORP.)
(C)

M - MILLIAMMETER, 10 MA.
T - 100,000-OHM THERMISTOR
(D)

Fig. 4. Circuit arrangements for four applications of the universal control amplifier. (A) Phono amplifier, (B) light flasher, (C) photoelectric relay, (D) temperature meter.

current is 100 ma. The input current will then be about 13 μa. Increase the resistance of R_1, the output control, until the output current drops to 50 ma. Note that further increases in the input current will not increase the output above 50 ma., showing the clamping action of R_1. Disconnect both meters and return R_1 and R_2 to their zero settings. The control is now ready for use.

Applications

Circuit arrangements for four applications of this control circuit are shown in Fig. 4, but many other uses are possible. For example, the control circuit may be used as a pulse generator by replacing the pilot lamp in Fig. 4B with a 100-ohm, 1-watt resistor, with the output taken from BP_3.

Fig. 4D suggests a variety of other meter applications such as a light meter, field-strength meter, or voltmeter, using any available meter movement from 5 ma. to 100 ma.

The relay circuit of Fig. 4C is extremely sensitive and may be used with any 3-volt d.c. relay having a closing current less than 100 ma. and may be operated from a voltage input such as the B2M photocell shown, or a current input from a cadmium sulphide photocell plugged into J_1.

Most of the fun in building this device is in discovering the many things it will do. ▲

SNEE-ZEE-I, *ITS CAUSE & CURE*

By **HARTLAND B. SMITH**

Remedies for "sneeze-operated" television set remote control.

AMATEUR radio operators consider the advent of television as a rather mixed blessing. Among the useful by-products of this new mode of broadcasting are the cascode amplifier and the nuvistor which have contributed to improved ham-band reception. In addition, the development of horizontal amplifier tubes, like the 6DQ6, now make possible the construction of inexpensive transmitters boasting respectable power ratings. On the other hand, TVI of one sort or another is still such a problem that activity on the high-frequency amateur bands shows a significant drop during prime viewing hours.

Unfortunately, another form of interference, "Snee-Zee-I," has recently come to light. Among the first reported victims of this phenomenon is W8YGI, James Abbott, of Birmingham, Michigan. One evening, not long ago, he and his wife were engrossed in the plot of an exciting whodunnit originating from the local channel 2 outlet. Suddenly, Mr. Abbott was seized with a severe fit of sneezing. When he finally regained his composure, the screen of the TV set displayed a channel 7 wrestling match. To his surprise and his wife's annoyance, supersonic components of Abbott's sneezes had triggered the receiver's remote tuning mechanism.

Luckily, there is a simple cure for this latest type of interference. A low-pass filter, fashioned from a large handkerchief or a number of facial tissues, can be placed over the face to muffle high frequencies generated by even the most powerful sneeze. Readers who own supersonically tuned TV sets and who suffer from hay fever or the common cold are advised to keep a supply of these filters on hand at all times. Otherwise, a great deal of friction may arise between the channel-switching sneezer and those members of the family who enjoy looking at a single program from beginning to end. ▲

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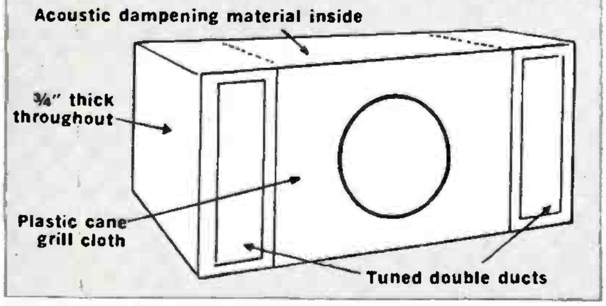

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Reprint of Mr. Canby's complete review of Cabinart speaker systems is available on request.

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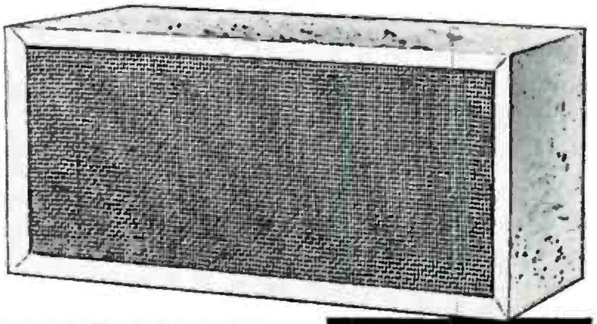

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1962 BRITISH TV TRENDS

By **PATRICK HALLIDAY**

A summary of the directions that are being taken by British TV manufacturers in their new lines of sets.

BRITISH TV manufacturers, facing receiver production figures which have been halved since the 1959 boom, have clashed on the best way of tackling the present uncertainty on future British TV transmission standards (see ELECTRONICS WORLD, September 1960 issue). Government delays in reaching a firm decision on when and if there will be a change from the present 405-line system to 625 lines (as used throughout Continental Europe) are held to be one reason for slow replacement sales. The Pilkington Committee, set up to advise on the future of British TV, is not expected to report until well into 1962.

At the recent National Radio Show in London—which attracted over 380,000 visitors—the influential *Pye Group* shocked more conservative makers by featuring a dual-line standard model capable of switching immediately from 405- to 625-line systems. Other makers, pointing out that many details of future transmission standards remain uncertain (AM or FM sound, positive or negative video modulation), have been content to introduce "convertible" models which, although operating solely on 405 lines, could be converted fairly simply to make them switchable to 625 lines. One maker even guarantees to do this free of charge if 625-line programs are announced before the end of 1962.

The problem of designing receivers to operate on both systems is not confined to changing the horizontal frequency from 10,125 cps to 15,625 cps (closeness of the European 625 frequency to the U.S. 525 frequency is due to the use of 50 fields instead of 60 fields per second). Provision must be made for possible changes from positive to negative video modulation and AM to FM sound modulation, a different i.f. bandwidth, and the use of intercarrier techniques. The extra circuits in the *Pye* switchable 19-inch receiver add about $40 to the price.

Most viewers who watched the side-by-side demonstrations of 405- and 625-line pictures seemed to consider the improvement only marginal and hardly worth the upset to receiving and transmitting equipment.

Attracting greater public interest were the *BBC* color demonstrations. Despite experimental transmissions for a number of years using the NTSC system scaled to 405 lines, no regular color service has yet been announced in Britain. Demonstrations have also been given in London recently of the 625-line SECAM color system which is currently being worked on by the *British General Electric Company* in conjunction with the *Compagnie Francais de Television*. This is a compatible system developed in France by Henri de France. It uses a sequential method of transmitting the chrominance information.

Domestic color TV receivers seen in Britain so far have used *RCA* shadow-mask picture tubes but extensive work on new forms of color display is being pursued. A new color tube demonstrated recently by *Sylvania-Thorn* has been named the "Zebra" tube because the screen consists of vertical stripes of red, green, and blue phosphors, rather in the manner of the *Philco* "Apple" tube. The zebra tube uses photoelectric cells to furnish an index signal which "tells" the receiver which color stripe is being activated. The photoelectric cells receive light signals from a set of index stripes on the rear side of the aluminum deposit. The tube is claimed to be simpler than the shadow-mask tube but requires more complex receiver circuitry. Like the recently announced *Mullard* "Banana" tube (ELECTRONICS WORLD, September 1961 issue), it is recognized that further development is needed if the tube is to be used for domestic color receivers. An advantage for monochrome use is that all color circuits can be switched off for black-and-white reproduction.

Standard TV receivers increasingly feature remote control in conjunction with motorized tuner units. Many of the remote-control units are connected to the sets by multi-core cable but there are also an increasing number of supersonic systems.

Most popular picture size in Britain is still 17 inches but this seems likely to be displaced soon by the 19-inch tube. These two picture sizes account for more than 88 per-cent of all sales. Average price of a 19-inch model, including the government purchase tax, is around $190.

About 10 per-cent of British TV receivers include facilities for the reception of FM sound broadcasts. Early models used the normal TV receiver's sound i.f. of 38.15 mc. for this purpose, but such models had a tendency to suffer from adjacent-channel interference. Most makers now incorporate a separate 10.7-mc. strip or use dual-i. f. units.

Although three transistor TV receivers have now been introduced in Britain, there is no rush by makers into this field. A new *Perdio* transistor model measures 10" x 6" x 18" and weighs 20 pounds. It has an 8½" picture tube with 27 transistors, 14 diodes, a zener diode, and two selenium rectifiers. Consumption is 1.1 amps at 12 volts or it may be operated direct from the power lines. Price is about $285. ▲

Ailing Picture Tubes
(*Continued from page* 48)

and the position of a selector pin that chooses either of two taps on the secondary, one can choose boosted voltage for a parallel filament, boost for a series filament, or normal voltage with isolation from the filament source.

To get an idea of what this unit can do, take the case of a filament-to-cathode short or leakage. Since one connection to the filament winding of the receiver's power transformer is customarily grounded, the short provides an alternate return path for the cathode circuit, upsetting CRT operation. With the restorer used simply as an isolation transformer for the heater (Fig. 8A), this path is removed. Cathode and heater can be operated at the same potential, with no disturbance to the cathode circuit.

If a short should develop between cathode and control grid, or the latter should open, it is possible to forget about that electrode altogether and to use the second grid (first anode) in its place, as in Fig. 8B. The potentiometer is used to adjust for proper bias.

Conclusion

Knowing how to isolate the various, possible CRT defects, what can and cannot be done about them, and how they relate to the life and quality of the tube is only the first step in deciding whether to replace, try a repair, or scrap the set. The decision ultimately involves other considerations, many of which are personal rather than technical. For example, the fact that the receiver in question is an old one used as a second set in the children's playroom may carry as much weight as anything else. Thus the owner, rather than the technician, is responsible for the decision. However, the former is entitled to an informed evaluation of the possibilities before he makes up his own mind, and the man he calls on for service must be able to supply this, in addition to being able to carry out the owner's decision.

Often the owner, reluctant to assume full responsibility himself, wants his service technician to take part in the decision. Here is where testers take on added importance. One can "let the equipment decide."

A final note: in many states, there is legislation covering the rejuvenation and repair of picture tubes. In effect, this makes it illegal to apply some of the remedies suggested here *without full disclosure to the owner of what is being done*. The intent is to prevent such unethical procedures as charging the customer for a new picture tube when all he receives is the repair of the old one or a rebuilt replacement. Complete discussion with the owner has already been recommended. When legislation exists, such disclosure becomes even more important. With this honest approach, no technician need fear to undertake any honest procedure. ▲

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Regulated Supply

(*Continued from page* 53)

This particular circuit is capable of supplying between 7 and 27 volts at currents up to one ampere. The high-current pass transistor (V_2) must have a maximum collector current of at least one ampere. It must also have a maximum collector-to-emitter voltage equal to the unregulated supply voltage minus the minimum output voltage. A Type 2N441 transistor with a maximum collector current of 15 amperes and maximum collector-to-emitter voltage of 40 volts was chosen. It is driven by a 2N378 transistor connected as another emitter-follower. This second emitter-follower must be able to supply the base current of the 2N441 and have the same collector-to-emitter voltage rating.

The difference amplifier employs 2N217 transistors which have a d.c. current gain of about 70. A 500-$\mu\mu$f. electrolytic capacitor across the output further reduces the a.c. output impedance and the ripple.

Neither of the output terminals of the regulator is grounded to the chassis. A third binding post is provided on the panel permitting the technician to ground either side of the output circuit. This permits the supply to be used with either *p-n-p* or *n-p-n* transistors.

The unregulated portion of the supply consists of a 25-volt, 1-amp filament transformer feeding a bridge rectifier and a capacitor filter. The bridge rectifier in the author's unit is made up of four 10-amp silicon diodes (SR_1—SR_4). Any bridge with a 1-amp current capacity is satisfactory. The 250-μf. capacitor across the bridge (C_1) filters the pulsating d.c. output of the rectifier.

Construction

The power supply is built in a 5" x 6" x 9" aluminum utility box. The 2N441 is mounted on a 4½" x 8½" plate of ⅛" thick aluminum which serves as the heat sink. The transistor is mounted with a mica washer to insulate it from the plate electrically while providing good thermal conductivity. The bridge rectifier diodes, the filter capacitors, and the remainder of the regulator circuit components are assembled on a phenolic sheet which is mounted with stand-offs on the heat sink. The transformer is mounted on the bottom of the box. The transformer, circuit board, and front-panel components are interconnected with a cabled harness.

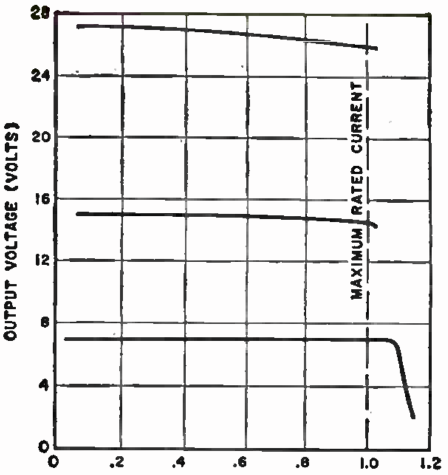


Fig. 2. Performance curves illustrate the excellent voltage regulation of unit.

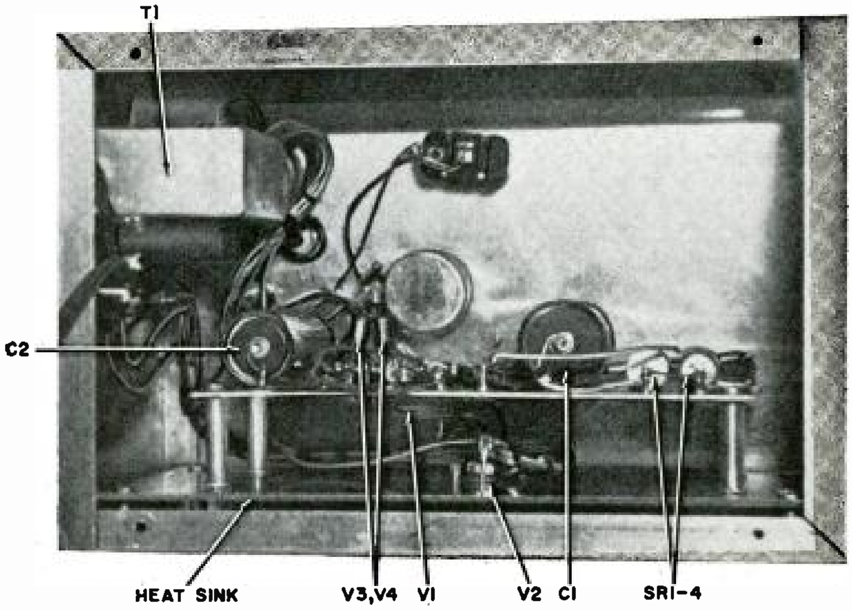
Operation

The heat sink provided for the high-current transistor in this unit is sufficient for most operating conditions. However, if the regulator is to be used to supply low voltages at one ampere for some length of time, it might be advisable to increase the size of the heat sink or put a fan in the cabinet to aid in cooling the pass transistor V_2.

The voltage regulation is excellent, as can be seen from the curves of Fig. 2.

This supply will provide a valuable addition to any laboratory and the amount of time and effort necessary to construct it will be well repaid. ▲

A rectangular aluminum plate serves as heat sink for the 2N441.



Making the Most of Meters

(*Continued from page* 55)

you do this three times, obtain slightly different answers in each case, and then average them out, you should be very close to the actual value.

Voltmeter & Ammeter Applications

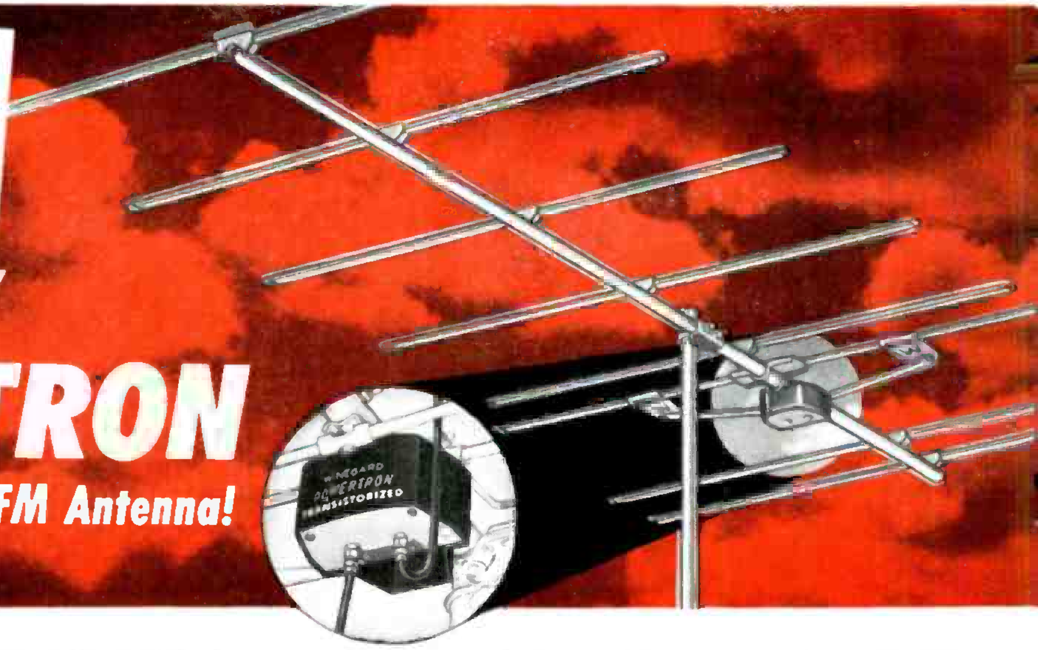
With full-scale current and internal resistance known, adapting a basic movement to a particular application is no great problem. Procedures will be reviewed briefly. For voltmeter application, you will generally need a series dropping (multiplier) resistor. Assume a movement that requires 1 ma. for full-scale deflection and whose resistance is 100 ohms. For a certain project, you want it to read 0-200 volts. Once more Ohm's Law comes into play, this time to determine the total resistance needed across 200 volts to produce full-scale current: $R_t = E_f/I_f$, where R_t is the total resistance (movement plus multiplier) needed, E_f is the maximum voltage to be read at full scale, and I_f is full-scale current. 200 divided by .001 gives an answer of 200,000 ohms.

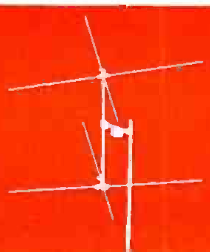
If the meter resistance is a large part of this total value, or if you want exceptional precision, you can subtract the former quantity from the latter to obtain the value for the multiplier. In most cases, as in this one, the answer to the formula can be used directly as the multiplier value. Here the error would be only 1/20 of 1 per-cent.

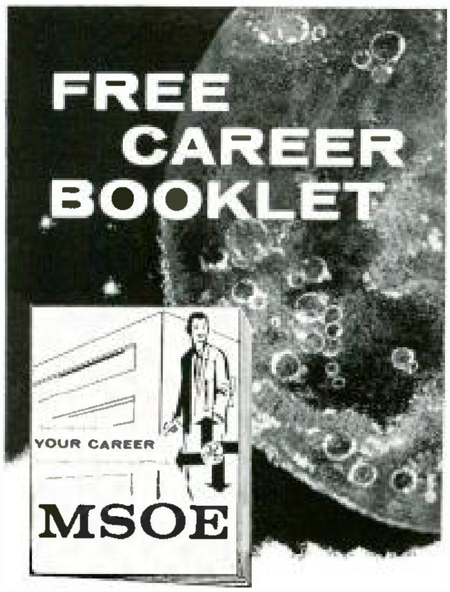
Let us say that, with the same basic movement used in the preceding example, you want a meter that will indicate 100 ma. full scale. You need a shunt across the terminals that will allow 99 ma. to flow around the movement while 1 ma. passes through the latter. Value of the shunt may be computed as follows: $R_s = I_f R_m / I_s$. R_s is the value of the shunt, I_f the current for full-scale deflection of the movement, R_m the internal resistance of the movement, and I_s the current to be absorbed by the shunt resistor. For the movement under discussion, the appropriate shunt would be 1.01 ohms.

In some applications, this parallel resistor may have to take quite a bit of current. It is a good idea to calculate the maximum power that will be dropped across it, and to choose one whose power rating is double that value.

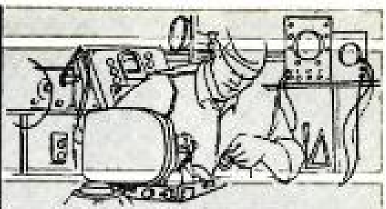
With full-scale values determined for your application, you only have to calibrate the rest of the meter scale to suit the requirement. You may be able to make your markings directly on the old scale. If you want a new scale, you can trace it from the old one, making sure that the zero and maximum-deflection points are accurately placed. You can check with a protractor. Then, still using the protractor, you can mark off the new scale accurately in the desired number of divisions. Values can be lettered in by hand or the scale can be put in a typewriter before it is inserted in the meter. ▲

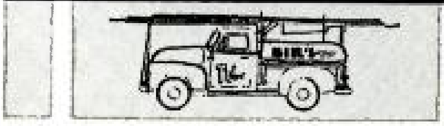






SERVICE INDUSTRY NEWS





THE PERENNIAL question as to why service shops, on the average, do not tend to stay in business for too many years gets another going over, this time a rather impressive treatment by Frank J. Moch in the "NATESA Scope." Of particular interest is the fact that he primarily deals, not with new businesses that fail to get a foothold, but those already established.

The most obvious cause of loss of business is loss of customers. Relying on nation-wide statistics, Moch points out that the average business loses 15 per-cent of its customers every year. "In ten years," he continues, "this is compounded to a loss of 81 per-cent." This average, however, includes the alertly run businesses that have succeeded in minimizing such losses. The actual loss percentage for the greater number of ordinary establishments would therefore be higher.

The conclusion that is most obvious to Frank Moch is embodied in his questioning how any business can justify saying, "We never advertise." Then he probes a little more deeply, with more statistics. Why do customers leave? Death takes 1 per-cent, 3 per-cent move away, 5 per-cent are influenced by others, 9 per-cent are enticed by lower prices. In this group, there is 4 per-cent about which the businessman can do little or nothing. In addition, 14 per-cent leave because of unadjusted complaints and 68 per-cent on account of bad treatment, poor service, and indifference. Put blunty, 82 out of 100 lost customers can be attributed to negligence or incompetence in one form or another.

Following up and mollifying disgruntled customers and other techniques involved in preventing loss of accounts, the writer acknowledges, are not always easy methods for a small businessman to work out on his own. Big businesses can manage this because they are in the position of being able to hire armies of specialists. How can a one-man shop match such an effort? By getting together with others in like position, so that a "big-business" approach is feasible for all in common. "Where else but in associations can you tap this pool of know-how? . . . Death for small TV-radio service businesses is *not* inevitable."

The writer's "pitch" is not a new one. But he makes a convincing case.

The Retail-Wholesale Problem

Frank Moch is evidently a very busy man. At the same time that he was tangling with the foregoing problem, he walked head-on into another. Readers will recall an item in this space (November 1961, page 99) concerning a setback to the entire service industry embodied in an opinion by the Federal Trade Commission. A member of the Television Service Association of Delaware Valley, Leon Skalish, had complained to the FTC about distributors who, taking advantage of their longer discounts, undercut service retailers by selling at lower prices to the general public. The widely held assumption, for years, has been that this must flout existing legislation devised to protect fair competition.

The FTC reply noted that "a distributor is under no legal obligation" to drop this practice, that he "is simply making use of his lawful competitive advantage." If there is no law, Moch feels, there ought to be one; so he has taken the problem to the man at the top. Vehement argument for such legislation was included in a letter he dispatched to President Kennedy and which was reprinted by "TSA-DV News" as a page-one editorial.

Industry Liaison Group

While TSA of Delaware Valley, not a member group in NATESA, is happy with the Moch-to-Kennedy letter, it has some qualification about current attempts to set up a unified industry council, in which all segments of electronics are to be represented, to deal with mutual problems.

"I wholeheartedly approve of the efforts," says Allen Roberts of TSA-DV. What bothers him is that independent service is being represented by NATESA exclusively: "I believe that *all* service groups should have been notified of the meeting and its purpose, giving them the opportunity to have their representatives in attendance or authorize NATESA to speak for them. This would certainly give NATESA a much stronger hand."

Court Test for Licensing

Missouri is not the only state in which a service licensing law has been challenged in the courts. Legality of the pioneer bill in Detroit, Michigan, was called into question after having been in effect for a number of years. A TV service dealer contended that the presence of four competitors on the nine-member board posed a threat of discrimination against him. The State Supreme Court in Lansing upheld the ordinance unanimously as a valid exercise of police power, citing other regulating bodies that have members representing the controlled business.

Twilight Operators

TESA of Miami is asking the help of all members and legitimate non-members in a new project. "New people daily are going into the business of servicing," it reports. "Many of them do not operate quite in compliance with local, legal, and zoning requirements." The group is asking reports on the names and addresses of such servicers, new or old.

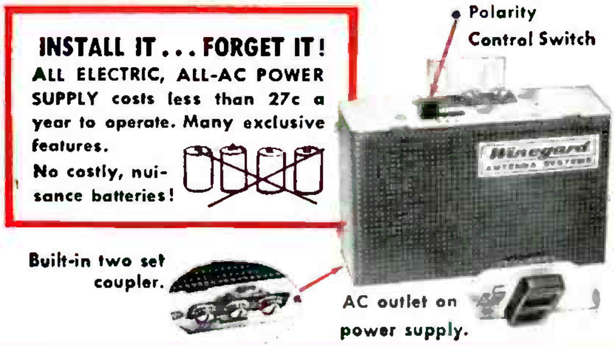
Many associations have undertaken such policing programs in the past and are doing so right now. The Miami venture, however, offers an interesting twist. What do they plan to do with an illegal operator? "We will write him a courteous letter explaining the requirements necessary for legal operation of a servicing business and offer assistance in avoiding pitfalls which could ruin him. This is a genuine proposal . . . and involves no obligation." This alert group merits commendation for its willingness to encourage *fair and honest* competition.

Color and Service's Future

In a Chicago speech, *RCA* President John L. Burns announced that his company's color-TV production lines are operating at high capacity with heavy back orders. Dealer orders have nearly doubled over last year. In fact, in Chicago itself, *"RCA Victor* sales, in actual dollars, were substantially greater for color than they were for black-and-white." He also noted that "color television is the only major new consumer durable on the market today." He projected as a major goal for the future a color-TV market "surpassing in volume and profitability our greatest years in black-and-white."

All this is good news to progressive, independent servicers, who will be at least as pleased with another point made by Burns. Despite his company's fast growth in other fields of the electronics industry, he states, "Our consumer-entertainment business accounts for and will continue to account for the major single share of *RCA* sales and revenue." Readers of "Industrial Electronics *vs* TV Service," on page 51 of this issue, will have to weigh this possibility before they give up on the future of consumer service.

For those of you who have been thinking in terms of a saturated black-and-white market, a recent survey done for the *Kimble Glass Co.* offers some food for thought. It indicates that more than 24 per-cent of existing TV households now have two *or more* receivers. This figure shows an increase of nearly 5 per-cent compared to a similar survey taken two years ago. Sets are used, not only in the living room, but in dens, recreation rooms, and bedrooms. A few are used in other rooms. (Kitchens? Hallways?) ▲



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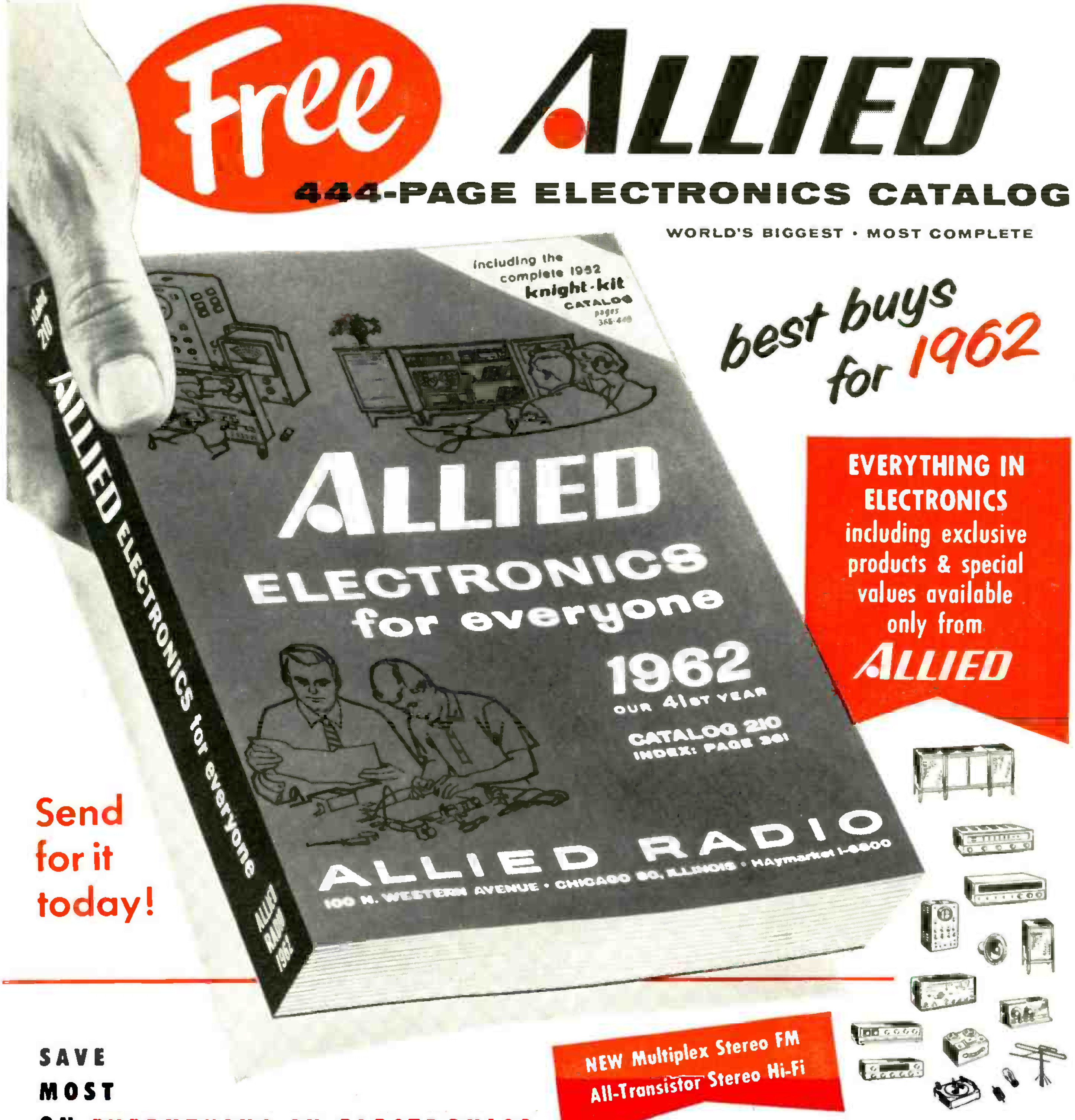

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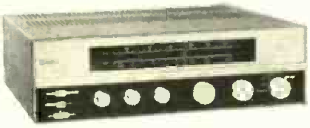

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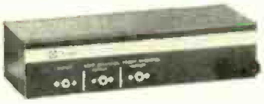

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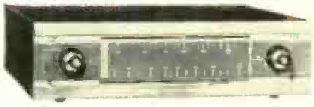

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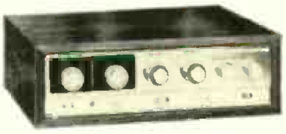

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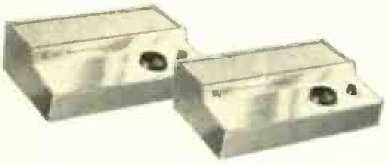

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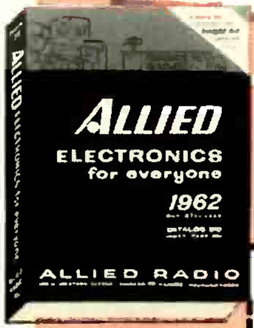

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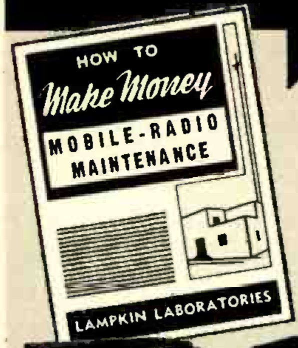

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(*Continued from page* 59)

ometers except a d.c. analogue voltage is made available at the output instead of the usual indicating meter. The signal for the recorder is furnished by a magnetized nut on the turbine shaft which is coupled to an inductive pickup coil in such a manner that each revolution of the shaft produces a pulse from the coil. Thus we have an a.c. signal whose frequency is directly related to turbine shaft speed.

The Calibration Process

Before we can proceed with the actual recording of data we must adjust the gain of each preamplifier unit to cover the range in which we are interested. This requires a calibration signal of some sort for each channel of data. Most of the plug-in preamplifier units contain a built-in precision "calibrate" signal which greatly simplifies the calibration process. Referring to the simplified version of a sample recording in Fig. 8, note the calibration marks at the beginning of each channel reading. These were determined as follows.

Since the range we wish to record for the air-turbine inlet temperature is determined to be 0-500 degrees Fahrenheit, we require a calibrate signal that will duplicate the output voltage of the thermocouple at this temperature. By consulting a set of tables for our particular reference junction temperature we find that an iron-constantan thermocouple with a 150-degree reference junction will have an output of 10.71 millivolts at 500 degrees F. We apply a duplicate signal from a precision millivolt source to the input of the preamp and adjust the gain to cover the appropriate range. Note that we do the same thing for 250 degrees in order to check the over-all system linearity. The thermocouple may now be connected and if our calibration procedure is correct, the recording stylus will rest on a point indicating ambient room temperature.

Since most commercial pressure transducers are of the full-bridge strain-gage type we can simulate a pressure calibration for air-turbine inlet pressure by paralleling one leg of the bridge with a precision resistor. This feature is built into the plug-in strain-gage preamp unit. By dialing the appropriate point on the precision variable resistor, we can select calibration points for any point within the range of the transducer. In the example of Fig. 8 calibration points are provided for 50 and 100 pounds-per-square-inch (psi).

As stated in the preceding section, the 400-cycle frequency-deviation preamplifier contains a precision 400-cycle tuning fork to allow the discriminator to be balanced at exactly 400 cycles. Since we must be able to read this channel of data correctly to 1 cps, an audio oscillator and a frequency counter would be used to set the recording range. In this manner the preamp gain is adjusted to record a scale of 375-425 cps with the 400-cycle point at the center of the channel. This completes the calibration for alternator frequency.

Assuming in the example for recording alternator load that we have unity power factor and a balanced load, we can provide accurate calibration points by observing a wattmeter while actually running the alternator under loaded conditions. This is often done when circuit conditions make a static calibration impractical and insures good over-all system accuracy. The recorder gain can be adjusted as desired as the different load points are applied.

A dynamic calibration is also desired for the alternator voltage since we wish to establish a greatly expanded scale for this channel of data. This can be done with an attenuator and a voltmeter. With the alternator running, the attenuator is adjusted to produce a reading on the voltmeter that corresponds to the lower limit of the scale we wish to record. As indicated in Fig. 8, this would be 100 volts.

In order to cancel out the first 100 volts of signal which we do not wish to record, the zero suppression circuit in the preamp is brought into use. This circuit provides a voltage of opposite polarity to the signal voltage which can be adjusted to buck out any portion of the total signal desired, allowing the remainder to be expanded as required. An upper limit is then established and the gain adjusted to cover the two points.

We have now established an expanded scale that allows us to record the 25-volt portion of interest from the total alternator voltage available.

The frequency-meter preamplifier contains a stable 400-cps calibrate source that can be used to establish a reference for turbine shaft speed. Since the speed pickup coil will produce one pulse for each revolution of the shaft, 1 cps would equal 60 rpm. Therefore, the 400-cycle calibrate signal would provide a reference point equal to 400 x 60 or 24,000 rpm. Thus we have a convenient reference point for setting the desired recording range.

A sample recording showing the results of one run is illustrated in simplified form in Fig. 8. Note that all pertinent information concerning the test is noted on the recording paper before the test begins. This permits a particular test run to be readily identified when a series is to be made. Points on the recording that might be of interest to the design engineer are turbine shaft speed *versus* alternator frequency, alternator voltage droop with load applied, alternator frequency recovery time with the load applied and removed, and air turbine inlet temperature *versus* pressure. These factors would indicate the over-all efficiency of the complete system.

This illustrates one industrial instrumentation problem that would be applicable to the direct-writing oscillograph. With the appropriate transducers and plug-in preamplifier units, this type of recording instrument can be used to advantage for almost any instrumentation application. ▲

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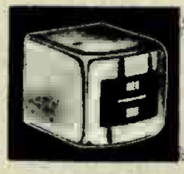

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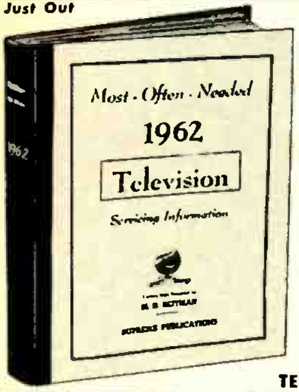

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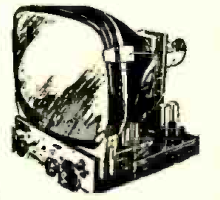

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Technical BOOKS

"SCIENCE & TECHNOLOGY STOCKS—A GUIDE FOR INVESTORS" by Grant Jeffery. Published by *World Publishing Company,* Cleveland. 330 pages. Price $1.95. Soft cover.

Although basically a book for the guidance of the investor, this phase is only a small part of the over-all treatment. Actually, the contents are of more value to the technician, engineer, and those in management positions in the field of electronics because the author projects into the future to outline potential electronic developments. Some of his thoughts are somewhat of the "blue sky" variety but they do give the reader a glimpse into the future.

One especially valuable feature of this volume is a section covering the "biographies" of 1000 companies involved in the electronics field. While this material is not a "directory," it does list the products, the number of shares outstanding, and the exchange on which the stock is traded. A careful perusal of this list offers many surprises in that many long-established firms in other lines are entering the electronics field in unprecedented numbers.

* * *

"EXPLAINING 'TEACHING MACHINES' AND PROGRAMMING" by David Cram. Published by *Fearon Publishers,* 828 Valencia St., San Francisco. 86 pages. Price $2.00. Soft cover.

Since many technicians are willy-nilly becoming involved in "teaching machines" by virtue of their technical know-how in installing and servicing such devices, this book may prove helpful in setting up lines of communication with the school administrators and teachers with whom they will be working.

This is not a technical manual to the extent that equipment is diagrammed and analyzed but the various programming methods are discussed in some detail along with the merits and drawbacks of each system.

* * *

"INDUSTRIAL ELECTRONICS MEASUREMENT & CONTROL" by Edward Bukstein. Published by *Howard W. Sams & Co., Inc.,* Indianapolis. 185 pages. Price $3.95. Soft cover.

Readers of this magazine are thoroughly familiar with the author's treatment of various phases of industrial controls and will find in this volume the same clear, concise, and practical exposition of the subject.

The book is divided into two parts with the first nine chapters covering measurement techniques and the second part dealing with control techniques. Components, circuits, and applications are described in sufficient detail to permit the reader to service and maintain industrial electronic equipment.

The treatment is such that the book is entirely suitable for self-instruction if desired.

* * *

"ELECTRONICS MATH SIMPLIFIED" by Alan Andrews. Published by *Howard W. Sams & Co., Inc.,* Indianapolis. 221 pages. Price $4.95. Soft cover.

For students and technicians in the electronics field who have encountered difficulties because of their lack of knowledge in handling the mathematics connected with their profession, this book is a boon.

The author's treatment of mathematics has been specifically planned to coincide with the study and application of electronics. All examples are related to electronics with the scope limited to basic algebra and trigonometry.

Many practice exercises are included in each section, with answers given in the back of the book for self-checking.

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"BASIC RADIO" by Marvin Tepper. Published by *John F. Rider Publisher, Inc.,* New York. 776 pages. Six volumes. Price $13.85. Soft covers.

This is a good and carefully written basic "course" in radio fundamentals which covers, in six volumes, d.c. electricity, a.c. electricity, electron tube circuits, AM and FM receivers, transistors, and AM and FM transmitters.

The more than 700 illustrations plus the author's inspired choice of language and analogy makes this the kind of "library" the student on his own will find as useful as the student taking the course in a technical institute.

No prerequisites are demanded of the student and the material is presented progressively to minimize misunderstandings and speed the learning process.

* * *

"DETECTOR AND RECTIFIER CIRCUITS" by Thomas M. Adams. Published by *Howard W. Sams & Co., Inc.*, Indianapolis. 126 pages. Price $2.95. Soft cover. Vol. 3 in "Basic Electronics Series."

This third volume in this publisher's series features dynamic circuit diagrams in full color enabling the reader to visualize exactly what action is occurring at every moment of detector and rectifier circuit operation.

The text material is divided into eight chapters which include an introduction to rectification and detection, half-wave rectifier circuits, full-wave rectifier circuits, diode and detector circuits, diode and detector with a.v.c., grid-leak detector circuits, discriminator circuits, and ratio-detector circuits.

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"HOW TO AVOID LAWSUITS IN TV, RADIO, APPLIANCE SALES & SERVICE" by Leo T. Parker. Published by *John F. Rider Publisher, Inc.*, New York. 66 pages. Price $1.00. Soft cover.

This book is not a short-cut to a law degree but it is a valuable manual for the technician wherein the legal pitfalls are pointed out in clear and uncomplicated languages.

The author, a practicing attorney who specializes in business cases, discusses when a serviceman can collect for repairs, when a service guarantee is enforceable, when a technician can demand cash payment, when a lien protects a serviceman, how knowledge of contract law can earn profits, what are the legal advantages of written contracts, how valid are written contracts, the law of insurance, and service order or contract. A glossary of terms is appended for the layman.

* * *

"INDUSTRIAL ELECTRONICS MADE EASY" by Tom Jaski. Published by *Gernsback Library, Inc.*, New York. 288 pages. Price $3.95. Soft cover.

Those contemplating the switch from consumer to industrial electronics servicing will find this book valuable in that it explains the similarities and differences in the two fields.

In addition, the author analyzes induction, dielectric, microwave, and supersonic generators and explains the techniques for transducers, control systems, and services. Counters, recorders, and other readout devices are described in some detail along with an explanation of the instruments employed in industrial electronics maintenance and their use.

The text is lavishly illustrated with photographs of commercial equipment, partial schematics, and line drawings.

* * *

"FM STEREO MULTIPLEXING" by Norman H. Crowhurst. Published by *John F. Rider Publisher, Inc.*, New York. 65 pages. Price $1.25. Soft cover.

This is a detailed description of the FCC standards for FM stereo broadcasting, the techniques involved in receiving such multiplex transmissions, as well as complete schematics of stereo FM adapters. Of particular interest to the technician are chapters on the installation and conversion, alignment and performance, checking and general trouble-shooting procedures to be used with FM stereo multiplex receivers.

Schematics, line drawings, and photos are used extensively.

* * *

"TRANSISTOR SUBSTITUTION HANDBOOK" by Sams Staff. Published by *Howard W. Sams & Co., Inc.*, Indianapolis. 112 pages. Price $1.50. Soft cover.

This is a newly revised edition which carries over 2300 more substitutions than before or over 8000 direct substitutions, 800 U.S. substitutes for Japanese types, and 630 semiconductor diode substitutes with special diode color code guide. There are basing diagrams, polarity identification, and makers listed for over 3000 types. ▲

Multiplex Detection Methods

(*Continued from page* 52)

maintain this phasing and the adapter at the receiver must use the pilot to produce a correctly phased regenerated subcarrier. Error in either can degrade separation.

Regenerating the subcarrier in correct phase has been achieved in three basic ways, with variations. The simplest is to isolate the pilot, amplify it, and double its frequency (Fig. 12). Other methods use an oscillator at either 19 or 38 kc. that is locked to the incoming pilot which is used as a synchronizing signal (Fig. 13). Each method has its varying relative merits as to stability of phase adjustment, purity of regenerated subcarrier, susceptibility to spurious synchronization, and so forth.

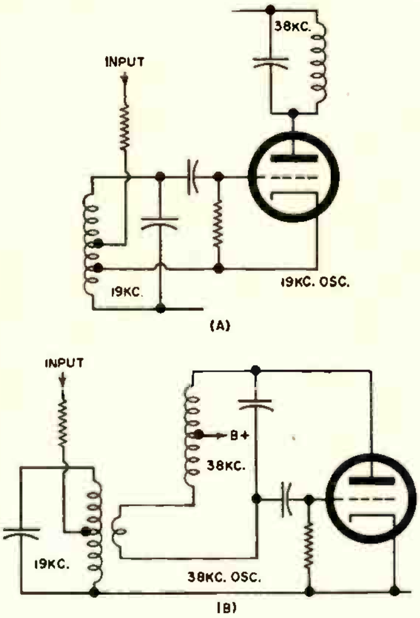

Fig. 13. Typical circuits using (A) 19-kc. and (B) 38-kc. oscillators to restore carrier.

When practical listening became possible, a limitation of the simple frequency doubler became evident. Received noise, or any intermodulation products, can appear as slight fluctuations in 19-kc. amplitude, which in turn appear as amplitude modulation of the 38-kc. regenerated subcarrier. The detector—whichever type—has no means of knowing whether the modulation it works on comes from the regenerated subcarrier or the transmitted modulation, so it appears with the program as noise. In theory, a switching circuit might have some advantages here, but this depends in practice on the use of a perfect switch, which doesn't occur in economically feasible designs.

This entry of noise is overcome when synchronized oscillators of either sort are used. The amplitude is stable and only the phase has to be locked by the incoming pilot.

Probably many areas will have good reception without any trouble from the SCA (background music) subcarriers. But because stations in several important areas will be combining both services, successful elimination of any SCA subcarrier breakthrough, or interference, is important on all adapters.

The first approach tried was a modified *m*-derived low-pass filter (or bandpass in some instances) designed to give a maximum rejection at 67 kc. or slightly below. This is intended to prevent reception of the SCA channel completely. But the filter does not necessarily eliminate any interference, in the form of "birdies," from the SCA channel. A very good band-reject filter, providing attenuation without spoiling the phase-linearity of the pass range, is needed to do this. This is quite a tough design problem.

The alternative many have found more successful concentrates on keeping the SCA subcarrier there, but making sure it has no *amplitude* modulation as well as its normal frequency modulation. Then, with linear detection, its presence produces no effect whatever. All this requires is very flat frequency response—no filters at all, except those needed to isolate the 19-kc. pilot—and a detection system, preferably of the envelope type, with very low distortion.

No matter how good a circuit may be in receiving stereo, it is apt to produce more noise on mono reception, due to the "open" subcarrier system, whatever circuit is employed. So several of the adapters have provided automatic switching facilities, controlled by the presence or absence of the 19-kc. pilot. This disables and bypasses the stereo operation, and ties both channels together as monophonic, when the 19-kc. pilot is absent.

Such an automatic circuit needs safeguards against spurious operation by noise, either interstation noise while tuning or random noise of fringe reception. This needs some kind of "logic" circuit that senses noise components not normally present in a good stereo transmission, and which would be present if a spurious 19-kc. signal were received.

The final feature needed in a good adapter is some form of output filtering. Whichever circuit is used, the left and right outputs will contain a fairly high and fluctuating amplitude of 38-kc. signal. In some amplifiers this could trigger instability. More important, it could produce birdies by beating with the bias oscillator of a tape recorder, should the user want to tape the transmission.

Whichever system is used, de-emphasis must be placed after the adapter, not before it. So, many adapters combine output filtering with the de-emphasis network for each channel.

That's the "state of the art" at the present writing. As we learn more about handling this new system, we find it isn't really so complex, merely unfamiliar. ▲

CB Antenna Matching

(Continued from page 41)

of power reflected back from the antenna because of impedance mismatch. The "useful" power—the power absorbed by the antenna—may be determined by subtracting reflected power from incident power. Using this technique, you can determine how well your antenna system is functioning.

If you operate your rig on more than one channel, try every channel you use and determine the efficiency you are getting. It may be necessary to optimize the tuning adjustments so that performance on all operative channels will be at approximately the same efficiency.

Antenna Impedance Adjustments

For optimum operation on a single channel, you can adjust the antenna impedance by cutting off the whip a quarter-inch at a time until the bi-directional r.f. power meter or the field-strength meter indicates maximum efficiency, retuning the transmitter every time you snip the antenna. If you use a telescoping antenna, move the antenna up and down a half-inch at a time until you find the optimum length.

Significance of Improvements

An increase of 6 db in effective radiated power (e.r.p.) doubles the signal strength at a distant receiver and, under some circumstances, doubles the range. To get a 6-db increase in e.r.p., it is necessary to quadruple the transmitter power (illegal if you are already running at 5 watts input), or the antenna must be replaced by a high-gain type which provides 6-db gain over the antenna you are now using.

While you probably don't have 6 db of loss in your base station and mobile antenna systems combined, you can nevertheless get more range through improvements in antenna efficiency at both ends. A 1.5-db improvement at the base station and another 1.5-db improvement at the mobile unit adds up to 3 db, which is equivalent to doubling the transmitter power.

The losses in the antenna system of a typical CB rig, however, seldom amount to as much as 1.5 db. A more realistic figure would be on the order of .5 to 1 db. When using a 20-foot run of RG-58/U cable, the loss under ideal conditions is .5 db. But for an SWR of 10, there would have to be a 10:1 mismatch of antenna to transmission line. Using typical antennas, mismatches are much smaller in practice, the SWR usually being less than 2.

If the base station transmission line is more than 20 feet long, the biggest improvement (if the antenna itself is satisfactory) can be achieved by using low-loss transmission line. Such line usually has a larger diameter and is costlier than the more commonly used coax. In addition, by tuning the transmitter properly and by using an antenna that properly matches the transmission line, e.r.p. can be increased an additional 3 to 10 per-cent. ▲

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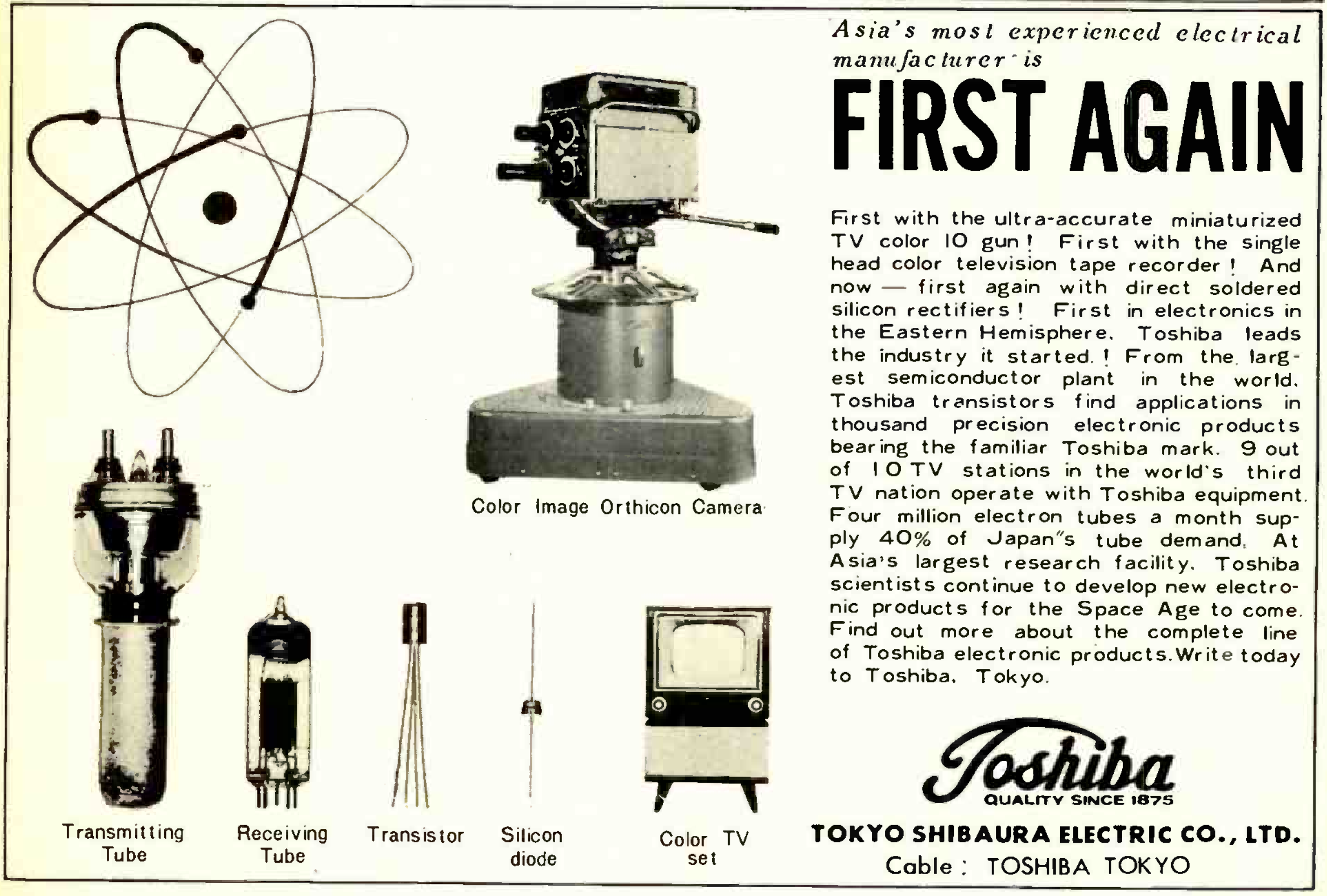

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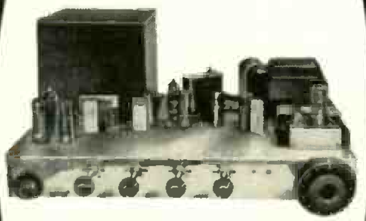

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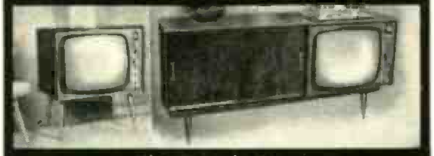

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Mac's Electronics Service

(Continued from page 56)

with audible sound, produce very little energy within the narrow 100-cycle bandpass at 38,000 cycles needed to affect the receiving sensor; but there is one exception to this: large amounts of ultrasonic sound energy issue from the exhaust ports of air-operated devices such as air drills, air-operated riveters, and air hammers. When one of these devices is operated very close to the receiving sensor, it can cause erratic operation. But the remedy is easy. I simply placed a fiber-glass table mat between the drill and the receiving sensor. That did it. The counter never budged even when the drill was almost touching the mat. The porous fiber-glass cloth absorbed the ultrasonic energy and attenuated it until it could not affect the receiving sensor."

"Nice going!" Mac applauded. "I wish I could have been with you. What do the sensors look like?"

"They are of hermetically sealed pod construction," Barney explained. "Since the exterior is all metal, they will take lots of abuse. The standard ones have a sending and response angle of about fifty degrees, but you can get 'focalizer' sensors that employ focussing reflectors to produce very narrow beamwidths. And, if you like, you can get units that are designed to couple to flexible tubing so that the ultrasonic sound can be conducted around corners and fed into places too small to take a regular sensor unit. With the proper combination of sensors, you can employ a beamwidth of several feet or one that will work through a hole .030 inch in diameter."

"What advantages are claimed for this system?"

"Well, it's not affected by ambient light, dust, industrial contamination, steam, smoke, or vibration. It will detect solids or liquids, opaque or transparent objects, ferrous or non-ferrous metals. Since the beam is invisible and inaudible, people are not tempted to 'try it out.' "

"Anyone who ever watched kids playing with the light-beam-control of a supermarket door opener can appreciate that last," Mac said with a chuckle. "You speak of detecting liquids. How does that work?"

"The liquid-level control uses only a single sensor of special design working with a slightly different amplifier," Barney explained. "The front face of this sensor oscillates freely at 38,000 cycles-per-second in the presence of air or gas; but when a liquid covers at least half the face of the sensor mounted horizontally or the whole face if mounted vertically, this mechanical damping of the oscillating element stops the ultrasonic oscillation, and the relay fed by the amplifier is actuated. Drops of liquid or a thin film of it clinging to the face will not prevent oscillation starting when the liquid level drops. It is claimed liquid levels can be controlled to within .005 inch with this system."

"I can see lots of ways you could use

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the two-sensor system," Mac reflected. "Not only could you make the system react when an object entered the beam path or when an object was removed from it; but, by bouncing sound off an object at an angle to the receiving sensor, you could detect any movement of that object. How fast will the system work?"

"It will count objects up to 1000 per minute," Barney answered promptly.

"You sure seem to have all the answers," Mac said admiringly. "I like the way you're going at this industrial servicing, Flamehead. As you know, I hope to do more than just service equipment already installed in the small factories that are our clients. I hope to be able to suggest new electronic equipment that can be used to solve particular problems in these factories. Really getting your teeth into a subject, as you obviously have done with this 'Sonac' equipment, is the best way in the world to prepare ourselves."

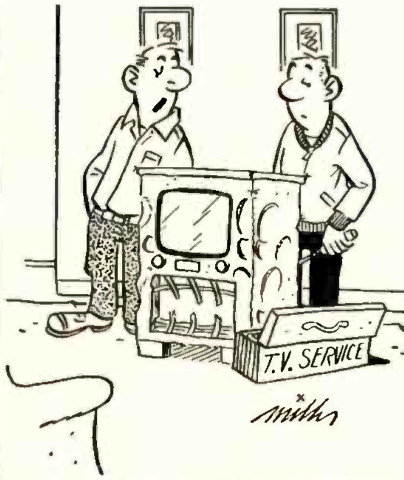
"That's the nicest thing anyone has said to me today," Barney said flippantly; but a broad grin revealed his pleasure at the commendation. ▲

USE CORK MATTING IN THE HAM SHACK

By **DONALD E. BEATY, W6WNR**

THE cork matting sold in variety stores for use on the dining table as a hot pad or a coaster has myriad uses around the ham shack. If you are dubious about stacking one piece of equipment on another in spite of a lack of bench space because of the danger of scratching, try gluing a large sheet of this material to the bottom of the top piece of equipment. You will find the resulting protection much superior to the more conventional rubber feet or felt pads. An added bonus comes from the fact that even the lightest piece of equipment will stay put until you deliberately move it. This is an obvious advantage when tuning a small converter or v.f.o.

A bug that refuses to stay put on the desk top can be a nuisance and even the heaviest keys seem prone to slide once in a while. Put one of these cork mats under your key and you'll think the bug has been bolted to the table top. ▲



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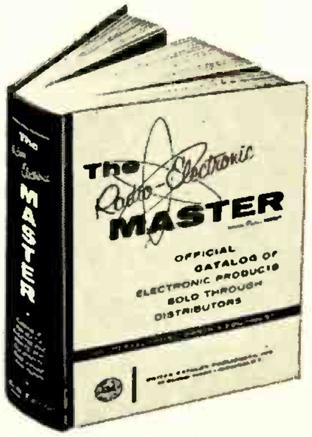

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Transducer Controlled Relay

By **SILOM HORWITZ**

Construction of simple thyratron-operated relay that may be used with any variable-resistance transducer, such as a photocell, a thermistor, or humidity sensor.

THERE are now available many different types of transducers which translate changes in physical states (such as humidity, temperature, light, and pressure) to changes in resistance. A change in resistance, of course, can be further translated into a change in voltage or current, which can then be used for control purposes. Because the most sensitive transducers normally can handle only milliwatts of power and devices to be controlled usually require many watts, the transducers are used as inputs to electronic controls which, in turn, operate the machines, the lights, or other devices as required.

The tremendous speeds at which electronic controls operate, however, can be a real problem when attempting to control devices which not only can't use such speeds, but may be damaged by too frequent cycling. On the one hand, we want to use the sensitivity of the electronic instrument but on the other hand the machine just cannot keep up with the cycling inherent in obtaining that sensitivity. This creates a dilemma, often solved by switching over to a less sensitive, non-electronic control.

As an example, consider the very simple operation required to sense humidity, turn on a dehumidifier when the humidity rises above a certain point, and then turn it off when the humidity goes below that same point. Simple? Since the "on-off" point is the same, the electronic device "hunts" back and forth, cycling too frequently, far beyond the capacity of the machine to follow.

As another example, consider a light-actuated control used to turn street, house, or garden lights on in the evening and off in the morning. At twilight, the light fluctuates because of atmospheric changes, clouds, etc. This condition, coupled with voltage changes in the a.c. line due to increased power demand, causes an uncorrected control to cycle on and off frequently until a stable condition (darkness) is reached.

It is obvious, therefore, that to use a resistive-type transducer with an electronic control device, some means must be found to create a differential, that is, a condition where the "on" point is different from the "off" point by a sufficient margin to prevent unwanted cycling. In other words, there must be a definite "on-off" snap action if the electronic control is to be practical.

Creating a Differential

There are a number of ways this can be accomplished, of which the following are representative of those found on commercial controls:

1. *Thermal lag.* The transducer controls a current which heats a thermal relay. This relay is a very slow-acting device (comparatively) which provides a pre-set time delay to prevent transients from operating the device and has sufficient lag to ensure positive operation. Although inexpensive, it removes some of the sensitivity of the transducer. Because of this, and the more or less fixed time-delay period, this method is limited to special-purpose applications.

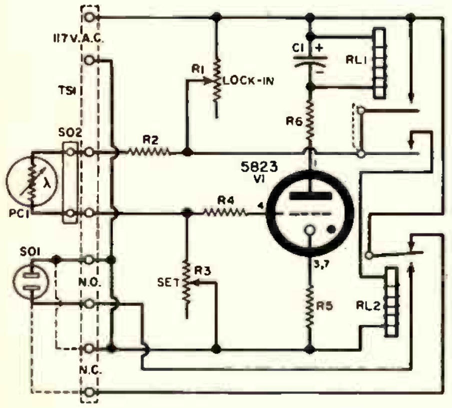
2. *Separate controls and/or circuitry for "on" and "off" states.* By paralleling controls and using a relay or electronic circuit to alternate between the two controlled conditions, very effective "snap action" is possible. This requires additional components, however, which can become rather expensive.

3. *RC time delay.* By loading a circuit with resistance and capacitance, it can be made sluggish enough to eliminate troubles due to transients, as well as to separate the "on" and "off" points. These points are, however, fixed (depending on component values selected) and time-delay periods have no actual relationship to transduced changes in value.

The transducer-controlled relay to be described uses none of the above methods specifically, but rather depends on "fooling" the control circuit into believing the transducer-reported condition is better or worse than it really is! This is accomplished by a "lock-in control"—a variable resistance which is normally included in the control resistance string, but is shorted out by the plate relay when the tube fires. This establishes a differential between "on" and "off" states, thus providing positive lock-in at either condition.

Otherwise, the circuit is a fairly straightforward cold-cathode thyratron-controlled relay. Although transistors have begun to almost monopolize new circuitry, many electronics development

The resistance of the transducer, in this case a cadmium sulfide photocell, forms part of a resistance voltage divider connected across the a.c. line. A tap on the divider goes to the control element of the thyratron. When the resistance of the transducer is reduced, due to an increase in light on the photocell, the thyratron conducts and both relays are energized. When a thermistor is used to detect temperature changes, the transducer resistance falls with an increase in temperature. With a humidity-sensing transducer, resistance falls when the humidity increases, thus energizing the relays.



R_1—100,000 ohm var. res.
R_2—100,000 ohm, ½ w. res.
R_3—3 megohm var. res.
R_4—22,000 ohm, ½ w. res.
R_5—560 ohm, 1 w. res.
R_6—1000 ohm, 1 w. res.
C_1—30 µf., 150 v. elec. capacitor
RL_1—D.p.s.t. plate relay, 2500 ohm coil (Guardian 1R-625-10, P&B GB11D-2500, or equiv. Any surplus relay of 2500 to 4000 ohms can be used.)
RL_2—S.p.d.t. power relay, 115 v. coil, 15 amp. contacts (P&B PR5AY-115V can be used. Author used surplus 10-amp d.p.d.t. relay with contacts wired in parallel for higher power. See text.)
SO_1—A.c. socket
SO_2—Crystal socket (Elco Type 430)
PC_1—Photocell or other transducer (see text)
TS_1—Terminal board, 8 screw terminals
V_1—5823 cold-cathode thyratron
1—5" w. x 4" h. x 3" d. miniature cabinet (Bud AU-1028, C-1794, or equiv.)

people are beginning to take new hard looks at cold-cathode tubes because of their many advantage in a.c.-operated circuits, including: (*a*) elimination of transformer and fancy power-supply requirements; (*b*) operation directly across a.c. lines; and (*c*) the negligible standby power required (for example, less than .07 watt for the device in this article). Because the device is used across the line and the transducer jack and leads may be touched in setting it up for operation, an isolating resistor, R_2, is used to reduce maximum current from the transducer terminal to ground (greatest possible shock hazard) to less than one milliampere at 60 volts, which is not dangerous.

Construction

Although this device can be built in a smaller cabinet, a 5"x4"x3" size is recommended for convenience in mounting components. If larger relays than the ones specified are on hand, and the constructor wishes to use them, a larger cabinet may be necessary. The photos show an inexpensive utility cabinet for which a chassis panel was constructed of sheet aluminum. This was done in order to use the easier-working material, but a steel cabinet with attached chassis may be found more convenient.

Begin by locating the variable resistors on the front panel, then drill the holes and fasten them in place. Doing this first will eliminate the possibility of not leaving enough room for the other components. Locate the other parts (actual location will depend on the relays selected), mark hole positions, and drill all necessary holes. For minimum lead length, the power relay should be located on top of the chassis at the right, the plate relay below, and the tube socket above on the right side. In positioning components, make sure that sufficient space is left all around so the completed panel will fit in the cabinet.

In addition to the holes required to fasten the parts, three extra ones should be drilled in the chassis: one under each of the variable resistors and one between the socket and the relay. These are for leads and should be fitted with rubber grommets or metal eyelets for protection. Ordinary variety-store eyelets can be used by placing them in the holes, heads down and resting on a block of wood, then hitting the open ends lightly with a countersink. The teeth of the tool will split the ends and spread them perfectly against the sheet-metal chassis.

Lug-type terminal strips should be fastened at or near the positions shown in the photographs and the 8-terminal screw-type strip fastened to the rear of the chassis with two small angles. Use of the terminal strip makes possible the completion of the unit outside the cabinet which makes for a very neat, professional-looking job. In addition, if the device is to be wired into a circuit permanently, the terminals may be used rather than the sockets and plug required for "portable" applications.

Wiring should be neat, but lead length is unimportant, as there are no critical leads. Hookup wire as fine as #22 may be used for all circuit leads except those to and from the power relay, which should be #14 to allow control of circuits up to 15 amperes. Resistors are soldered, as shown, between lugs on the strips and component terminals. The capacitor may either be held in place with a clamp or, if one of the small-size electrolytics is used, soldered between circuit points in the same manner as the resistors. It will be found convenient to use two lugs under the chassis for the two sides of the line; by using red wire for the "top" side and black for the "bottom" one, wiring will be simpler and the circuit easier to trace during construction. Make certain that small components and leads are kept well away from the relay armatures so as not to interfere with their action.

One important point about connections to the plate relay: if the moving contact which makes connection to the power relay operates before the other, a path is provided from the top side of the line through R_1 and then to relay RL_2. If R_1 is set to a low resistance, it can be damaged by the surge. For this reason, carefully bend the contacts slightly so the contact which makes the connection to the line (and shorts out R_1) operates before the one which connects with the relay. Not much difference is required: even a thousandth of an inch is sufficient.

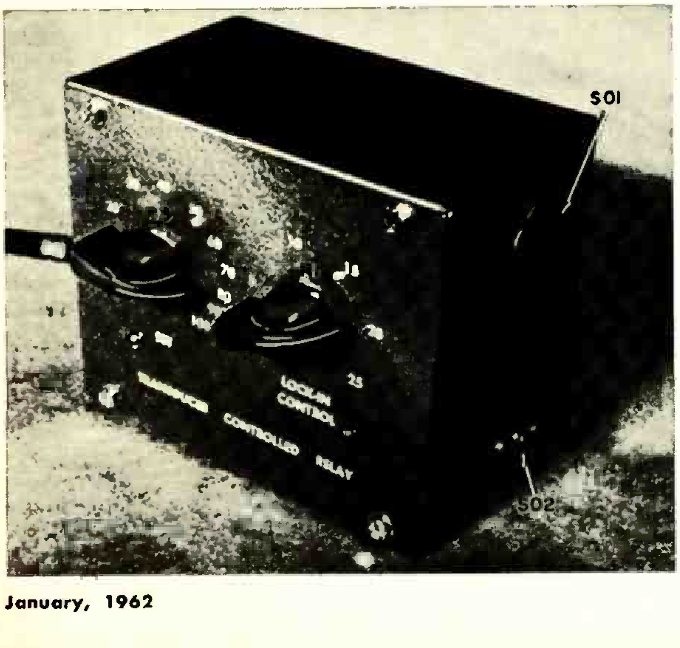
Testing & Adjustment

After all wiring is completed, connect a 2000-ohm resistor across the transducer terminals as a dummy input and measure the resistance across the power terminals. This should read a minimum of 100,000 ohms and can read over 3 megohms. Rotation of R_3 should vary this resistance over this range, keeping R_1 at minimum. If it does not, check the wiring and make necessary corrections. When the resistance readings are correct, connect a power cord to the a.c. terminals and plug in to 117 volts. *It is a good idea at this point to use an isolating transformer as full line current is available at many points on the chassis which may be touched.* Only a few watts are required so only a small transformer is needed. Two filament transformers back-to-back may be used for this purpose.

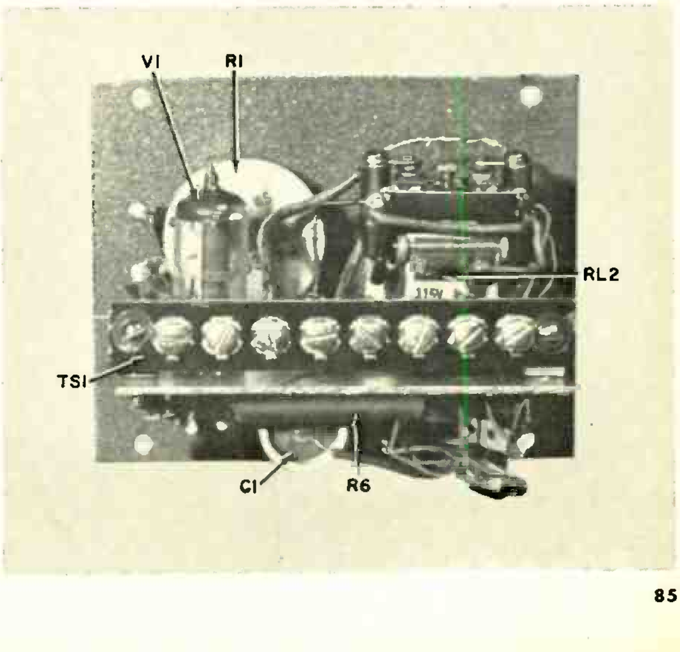
Now rotate R_3 (set control) until the tube fires (it will glow with a violet light) and note the operation of the relays. Both should operate. Reverse the rotation of the set control until the tube and the relays drop out. Now rotate R_1 (lock-in control) to maximum resistance and test the set control for "on" and "off" states. There should be a definite difference in shaft angle for these two conditions. Rotating the lock-in control to zero resistance should result in a critical point on the set control where "on" and "off" positions are almost identical. Rotation of the lock-in control provides positive lock-in through separation of the two points, and does it without parallel or time-delay circuitry, although the capacitor across the plate relay does provide a small amount of delay to inhibit transients.

If the device is to be wired permanently in location, it may now be placed

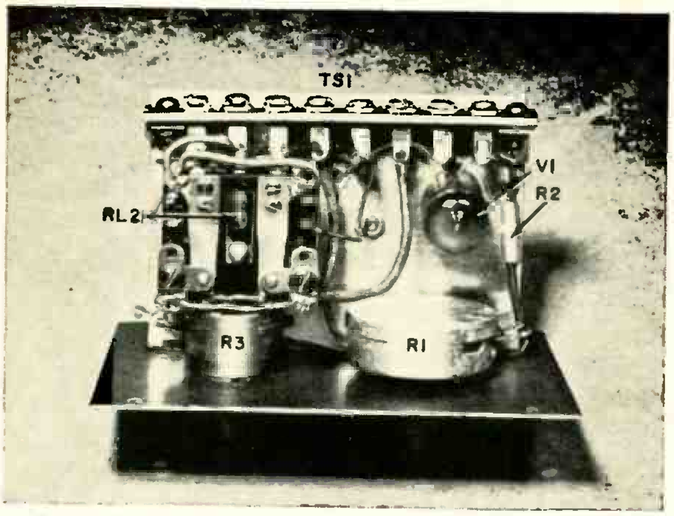
Over-all view of the relay unit built into a 5" x 4" x 3" cabinet.



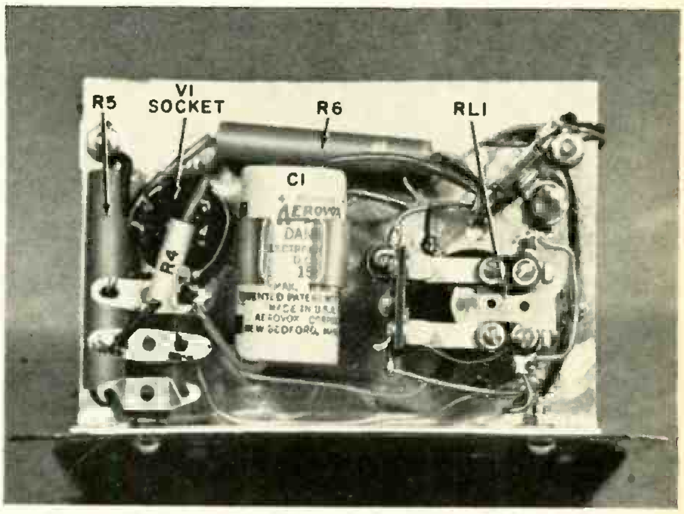
Rear view shows the terminal strip to which connections are made.



in its cabinet, but if it is to be a "portable" unit for multi-purpose applications, sockets for the controlled device and the transducer, as well as a power cord with plug, must be provided. The socket for the transducer should be different from the a.c. socket to prevent possible accidents. A crystal socket is inexpensive and readily available. Both sockets can be mounted on one side of the cabinet, as shown in the photos, or on the rear panel. In either case, be sure they are positioned so as not to contact any of the components.



Top of chassis shows pots, the power relay, and the thyratron.



The sensitive plate relay is attached to the underside of chassis.

After placing the panel and chassis assembly in the cabinet, leads from the sockets and the power cord are connected to the proper screw terminals. Depending on the use required of the device, the output socket should be connected to the "N.O." (normally open) or "N.C." (normally closed) terminals. The N.O. terminals control a machine or device which is to be activated by a reduction in transducer resistance while the N.C. terminals control a device which is to operate by a rise in transducer resistance.

To complete the unit, decals or other lettering should be applied to the front panel. If desired for a specific application, numerals indicating exact calibration can be used. If for general-purpose use, however, arbitrary numbers are better. The set control is not linear, so numbers should be spaced more closely for the minimum resistance portion of the rotation.

Applications

Many uses are possible for this device, three of which will be described in detail and the others suggested.

Originally the unit was designed to operate a dehumidifier. For this application, an *El-Tronics* humidity-sensing element has proven to be very satisfactory although the less expensive *Hygropak* humidity sensor will probably work for this purpose. To calibrate, two methods may be used. The first requires no external instrument as it relies on the resistance calibration furnished with the *El-Tronics* element. A variable resistance is set to the ohms indicated for the humidity percentage desired, then it is connected to the transducer terminals or socket. The set control (R_3) is rotated until the relay operates. This position is noted on the dial. The external resistance is then increased until the relay releases, and its resistance measured. This is compared with the transducer calibration and if the reading is more than two or three degrees different than the "on" setting, the resistance of the lock-in control (R_1) should be decreased, and another reading taken. This process is continued until the relay operates a few degrees above and releases at the desired "humidity," as indicated by the calibration on the humidity/resistance chart. In similar fashion, other percentages of humidity can be calibrated and noted on the set-control dial, as required.

The other method for calibrating is required when an uncalibrated transducer is used. A hygrometer, psychrometer, or other humidity indicator is required and should be located at the air intake of the dehumidifier. The dehumidifier is connected to the control relay and the set control rotated past the point where the relay operates and the machine functions. When the humidity, as indicated by the hygrometer or other instrument, reaches the percentage desired, the set control is rotated in the opposite direction until the relay just releases. By observing the operation, and referring to the indicator, the two controls can be adjusted so as to allow proper cycling of the dehumidifier. Once set, it need not be disturbed again for the particular percentage of humidity to which calibrated. If desired, of course, further calibration can be performed for multiple settings.

In another type of application, this device can be used to control an electric heater, furnace, or air conditioner, for which purpose it is much more accurate than the ordinary type of thermostat, as temperatures can be controlled to about one degree. For the transducer, a thermistor having a room temperature resistance of about 10,000 ohms is required. For increased sensitivity, two to four thermistors can be connected in series; this provides an increased resistance differential per degree change in temperature. If calibration is furnished with the thermistor, the relay can be set similar to the first method described, otherwise the second method must be used. As the relay must operate with a decrease in temperature, and release with an increase, the N.O. connections should be used with a heater and the N.C. with an air conditioner or other cooling device.

Another application for this device, and one for which it is admirably suited, is to turn lights on at dusk and off in the morning (or when you return home after a big evening!). For this purpose, a cadmium sulfide photocell (such as the *Clairex* CL-407 or CL-605, *RCA* 7412, or equivalent) is required. The light to be controlled is connected to the N.C. terminals, and the set control rotated at dusk until the light just goes on. The lock-in control should be at maximum resistance. When off, the large resistance of R_1 will prevent relay function until considerably more light is present, such as occurs after daybreak. This prevents cycling due to automobile and other transient lights and ensures positive operation. If the relay is to be used only for operating lights of less than 200 watts total, relay RL_2 may be omitted and a set of normally closed terminals on relay RL_1 used instead.

In addition to the applications described, the device can be used with a solenoid valve to turn water on and off depending on the resistance between two electrodes. For example, the electrodes can be stuck in the soil and detect (by increased resistance) when the ground is dry. In this type of application, incidentally, the device *must* be isolated from the ground through a transformer. As the standby power is almost nil, the device can be used with an infrared photocell to operate a fire alarm. It can also be used with strain and pressure transducers for a multitude of industrial applications.

In other words, whenever it is possible to sense a change in a physical condition by the use of a resistance-type transducer of any kind, this relay will function consistently at almost no cost during standby and at very little expense when operating. ▲

VACUUM-TUBE PUZZLE

By **LUTHER A. GOTWALD, JR.**

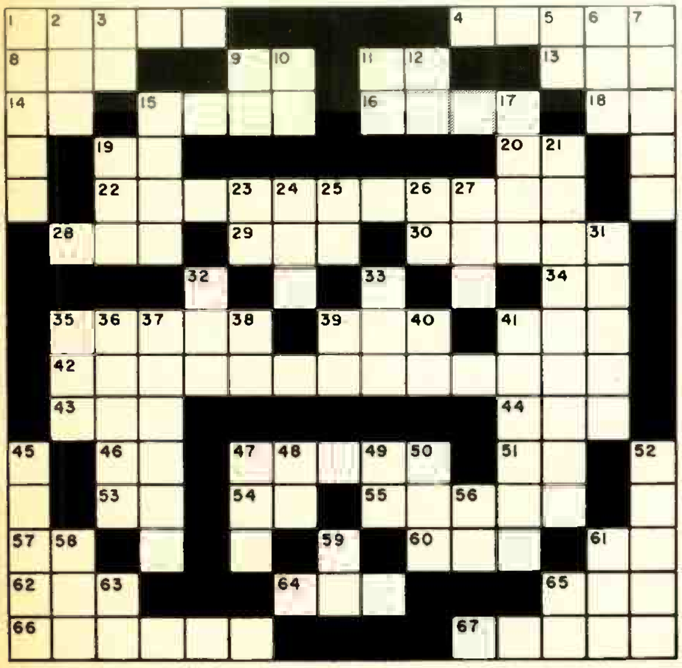
(*Answer on page* 97)

ACROSS

1. Roman garb.
4. Control electron flow.
8. A republic (abbr.).
9. Tube rating.
11. Amplifier type.
13. Imitate.
14. Designation for unused pin.
15. Voltage on grid.
16. Removes unwanted ions in CRT.
18. Under the word (abbr.).
19. Metric measure (abbr.).
20. English digraph.
22. Function of third grid.
28. Consumed.
29. Tube terminal.
30. Disentangle.
34. And (Latin).
35. Nodular stone.
39. Young fish.
41. Terminal for illegibly addressed mail (abbr.).
42. Function of an electronic tube.
43. To cease.
44. Wife of Saturn (Rom. Myth.).
46. Weight (abbr.).
47. Electronic unit.
51. From (prefix).
53. Element used in electronics (abbr.).
54. Transistor parameter.
55. Used in many electronic devices.
57. Unit of weight (abbr.).
60. Printing units.
61. Otherwise.
62. To compete.
64. Used in thyratrons.
65. Washroom (Brit. slang).
66. Early observer of electronic emission.
67. Positive terminal.

DOWN

1. Where a triode is often used in u.h.f. receivers.
2. Caused by feedback (abbr.).
3. State (abbr.).
5. Midwestern State (abbr.).
6. Political refugees (abbr.)
7. A number.
9. Current unit (abbr.).
10. "You and me."
11. Of a point in space.
12. Fraternal title (abbr.).
15. Mercury vapor glow.
17. A "table" game.
19. Summer time (abbr.).
21. Glass portion of tubes.
23. Amplifier output circuit (abbr.).
24. Ham equipment.
25. Letter of the alphabet.
26. Retirement insurance (abbr.).
27. Accompanies electrolytic decomposition.
31. Boy's jacket (pl.).
32. Bound objects (abbr.).
33. Current passing through the air.
35. Run about.
36. What a cathode does.
37. Switch position.
38. Formula for "watts."
39. Twin to "hi."
40. Adverb (slang).
41. Rectifier tubes.
45. "British" for tube.
47. Heater (abbr.).
48. Current to heaters (abbr.).
49. Crystal cut.
50. That which should be paid.
52. Chart to tube performance.
56. Tactical unit (abbr.).
58. Propose to pay.
59. Fourth tone of the musical scale.
61. A grain.
63. Input voltage (abbr.).
65. A tone.



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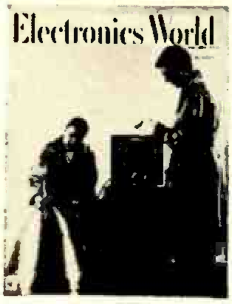

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THE MEXICAN ELECTRONICS MARKET

Preference is being given to locally made equipment.

THE rapid changes being effected in Mexico's industrial economy will have both short-range and long-range effects on U.S. manufacturers of electronics equipment for this export market. According to the U.S. Department of Commerce, new emphasis is being placed on "Made in Mexico" items with preferential treatment being given to local products. The Department of Commerce advises that most foreign firms interested in supplying the Mexican market will find it necessary to plan production of at least some of their products in Mexico.

In order to spur industrialization, the government is granting tax exemptions to new industries considered necessary to the Mexican economy and raising tariff barriers to sometimes prohibitive figures.

Thus far, Mexico has no domestic facilities for microwave, forward scatter, or radar equipment and only one small factory manufacturing high-frequency radio equipment. In addition, there are no present facilities for the manufacture of two-way v.h.f. radio equipment, but one British and one U.S. firm are reported to be considering setting up such a plant.

Since the largest telephone company in Mexico has just launched a 5-year expansion plan, the Department estimates that towers, substations for repeater stations in the microwave system, and microwave links will be required but notes that since most telephone equipment in Mexico is of European manufacture, the prospects for U.S. contracts for new equipment are poor.

The use of v.h.f. radio by industry is also expanding. Sales prospects are good, but up to mid-1961 there existed only a single large project, sponsored by *Petroles Mexicanos*, a semi-government agency.

Much interest exists in expanding the use of microwave in telephone and telegraph service, multi-channel links for control and communications, and television studio-to-transmitter and remote-control service.

U.S. equipment meets severe competition because of its higher prices, sometimes 40 per-cent higher than European apparatus of lower quality. Some Mexican consumers feel that U.S. radio communications equipment is more sophisticated than conditions in Mexico require. European and Japanese manufacturers also give long-term financing, sometimes up to 5 years, and frequently offer better and more complete servicing facilities than do U.S. suppliers. Another inducement offered by European manufacturers is the issuance of instructions and illustrative material in Spanish. ▲

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CALENDAR of EVENTS

JANUARY 9-11, 1962

Eighth National Symposium on Reliability & Quality Control. Sponsored by PGRQC, AIEE, ASQC, and EIA. Statler-Hilton Hotel, Washington, D.C. Program information from E. F. Jahr, IBM Corp., Dept. 351, Owego, N.Y.

JANUARY 18

Transformer Testing. Sponsored by N.Y. Metropolitan Chapter of Institute of Environmental Sciences. U.S. Testing Co. Laboratories, Hoboken, N.J. For program information contact Carl Hannemonn, 214 E. 105th St., New York 29, N.Y.

JANUARY 23-27

Third Annnal ERA Convention & Management Conference. Sponsored by Electronic Representatives Assn., Hollywood Beach Hotel, Hollywood Beach, Fla. Details from ERA headquarters, 600 S. Michigan Ave., Chicago 5, Ill.

FEBRUARY 7-9

1962 National Winter Convention on Military Electronics. Sponsored by PGMIL and L.A. Section of IRE. Ambassador Hotel, Los Angeles. Details from IRE Los Angeles Office, 1435 S. La Cienega Blvd., L.A., Calif.

FEBRUARY 9-11

Pacific Electronic Trade Show. Shrine Exposition Hall, Los Angeles. Information on exhibits and program available from PETS, 2216 S. Hill St., Los Angeles 7, Calif.

FEBRUARY 27-MARCH 1

Symposium on Application of Switching Theory in Space Technology. Sponsored by Lockheed Aircraft Corp. and AFOSR/General Physics Div. Contact Dr. J. P. Nach, c/o Lockheed, Sunnyvale, Calif. for details.

MARCH 1-2

Eighth Scintillation and Semiconductor Counter Symposium. Sponsored by PGNS, AIEE, AEC, NBS. Shoreham Hotel, Washington, D.C. Program information from Dr. George A. Morton, RCA Labs, Princeton, N.J.

MARCH 7-11

San Francisco Home and High Fidelity Show. Sponsored by Magnetic Recording Industry Assn. Cow Palace, San Francisco. Open to the public. Stereo FM multiplex broadcasting and receiving equipment will be featured.

MARCH 14-16

Twelfth Annual Conference on Instrumentation for the Iron & Steel Industry. Sponsored by Instrument Society of America. Hotel Roosevelt, Pittsburgh, Pa. Details from H. M. Gravatt, Allegheny Ludlum Steel Corp., Research Lab., Brackenridge, Pa.

MARCH 20-25

1962 Los Angeles High Fidelity Music Show. Sponsored by Institute of High Fidelity Manufacturers, Inc. The Ambassador Hotel, Los Angeles. Open to public March 21-25th.

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. ▲

MODULATION QUIZ

By JOE TERRA

Try your hand at matching the words in the first column with the definitions in the second, then check your answers on page 97.

1. Amplitude
2. Balanced
3. Center-tap
4. Clamp tube
5. Cross
6. Double
7. Downward
8. Heising
9. High-level
10. Intensity
11. Linear
12. Low-level
13. Percentage
14. Screen-grid

A. Type of screen modulation used with screen protective tube.
B. Carrier wave is first modulated with desired intelligence. Resulting wave is then used to modulate a second carrier having a different frequency.
C. Modulation introduced in the last radio stage or at a point in the system connected to the antenna.
D. Difference between maximum and minimum amplitudes divided by twice the mean amplitudes multiplied by 100.
E. Modulation which is equally proportional to the amplitude of the sound waves at all audio frequencies.
F. Common system of radio broadcasting.
G. Control of the brilliance of the trace on the screen of a cathode-ray tube in conformity with the signal.
H. Amplitude modulation applicable to r.f. amplifier tubes employing a screen grid.
I. Modulation introduced in the early stages of amplification.
J. Interference which modulates a signal undesirably, usually from some unwanted source.
K. Type of amplitude modulation most frequently used with beam tetrode r.f. amplifiers.
L. Used in single-sideband suppressed carrier radiotelephony.
M. Plates of r.f. amplifier and modulator tubes are fed through a common inductor of high impedance.
N. Abnormal modulation in which amplitude of the transmitter signal vari~s inversely with the level of sound to be transmitted.

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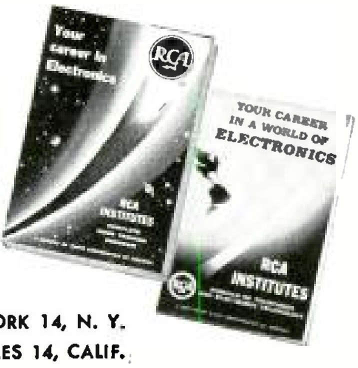

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ROBERT R. SHERWOOD, formerly vice-president of *Rek-O-Kut/Audax Co.*, has joined *University Loudspeakers, Inc.* as assistant to the president.

He brings to this new post a considerable background in modern management techniques that will be of assistance to the company in its extensive expansion and diversification program.

Mr. Sherwood attended Cornell University and has been associated with a number of firms in and out of the electronics field before joining the White Plains speaker firm.

* * *

HERMON H. SCOTT, president of *H. H. Scott, Inc.*, has been elected president of the Audio Engineering Society for 1961-1962. Serving with Mr. Scott are the following officers: executive vice-president, H. E. Roys, *RCA Victor Record Division;* central vice-president, A. B. Clapper, *Universal Recording Corporation;* western vice-president, William H. Thomas, *James B. Lansing Sound, Inc.;* secretary, C. J. LeBel, *Audio Devices, Inc.;* and treasurer, R. A. Schlegel, *Station WOR*, New York.

New Governors elected at the annual meeting include Harvey Sampson, Jr. of *Harvey Radio Company, Inc.;* Walter T. Selsted of *Ampex Corporation;* and Edward H. Uecke of *Capitol Records, Inc.*

* * *

WINEGARD COMPANY has just completed a new plant on an 8-acre site in Burlington, Iowa. The new facility provides 15,000 square feet of production area on one floor and will employ 120 people . . . **OLSON ELECTRONICS INCORPORATED** has just opened its eleventh branch at 485 Peachtree Street in Atlanta, Georgia. The Akron-based distributor plans several additional outlets in the near future . . . **TOKYO SHIBAURA ELECTRIC COMPANY** has moved its New York City offices to 530 Fifth Avenue . . . **ATLEE CORPORATION** has moved into its new plant at 2 Lowell Ave., Winchester, Mass. . . . **ADMIRAL CORPORATION** has begun construction of a 112,000-square-foot brick addition to its Harvard, Illinois facility . . . **ASTRA TECHNICAL INSTRUMENT CORP.** has moved to a new 15,000-square-foot building in Culver City, California . . . **CORNING GLASS WORKS** has started construction on a 120,000-square-foot electronic components plant at Raleigh, N.C. Operation is expected to begin next summer . . . The Semiconductor Division of **HOFFMAN ELECTRONICS CORPORATION** has consolidated its operations in its new and modern El Monte, California plant . . .

* * *

MACHLETT LABORATORIES, INC. has agreed to purchase the **CBS ELECTRONICS** plant in Danvers, Mass. . . . **MIRATEL ELECTRONICS, INC.** is doubling the size of its plant in New Brighton, Minn. . . . **FAIRCHILD SEMICONDUCTOR** has started construction of a new research and development center on a nine-acre site in Stanford Industrial Park, Palo Alto, California . . . **CASTLE TV TUNER SERVICE, INC.** of Chicago has opened a modern TV tuner service plant in Cliffside Park, N.J. to handle the requirements of eastern customers . . . **CLAIREX CORPORATION** has moved to 8 West 30th Street, New York City.

* * *

C. HARRY KNOWLES has been named assistant general manager for research and advanced development for *Motorola Semiconductor Products Inc.*

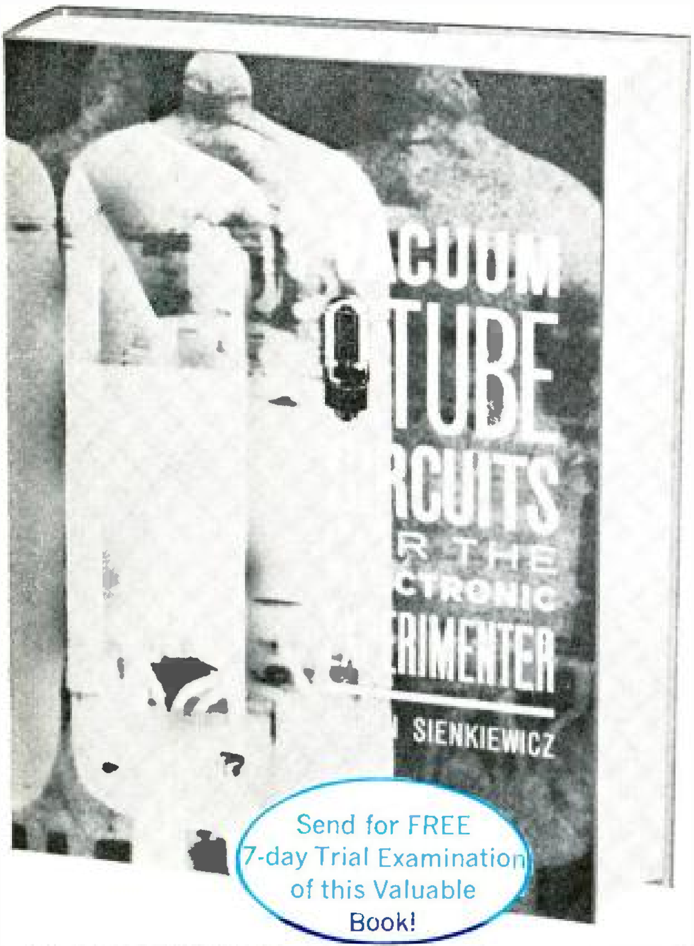
In his new capacity, Mr. Knowles will direct the company's efforts in the development of integrated circuit devices and other components. He will direct the division's activities in mechanization and circuit research. He was formerly product manager for the firm's mesa transistor products.

Before joining *Motorola* in 1958 he was a member of the technical staff of *Bell Telephone Laboratories*, Murray Hill, N.Y.

* * *

RAYTHEON COMPANY has purchased substantially all of the assets of **RHEEM SEMICONDUCTOR CORP.**, a subsidiary of **RHEEM MANUFACTURING COMPANY.** No details of the transaction were disclosed . . . **MIRATEL ELECTRONICS, INC.** has purchased all outstanding stock of **MID AMERICA RELAYS SYSTEMS, INC.** of Rapid City, S.D. . . . **STANDARD KOLLSMAN INDUSTRIES INC.** has established an English subsidiary, **KOLLSMAN INSTRUMENT LIMITED** of London . . . **NATIONAL RADIO INSTITUTE** has established a new division, **CONAR INSTRUMENTS,** which will offer a complete line of kit and assembled instruments and equipment . . . **RCA** has formed a data systems division in Van Nuys, California . . . **RAYTHEON COMPANY** has purchased all of the common and preferred shares of **A. C. COSSOR, LTD.** of London, its sixth subsidiary in Europe . . . **SUBURBAN PLASTICS CO. INC.** has formed a vacuum equipment and components division which will specialize in the design and manufacture of

Now you can build almost any kind of electronic device!



Here are the ABC's of 50 vacuum-tube circuits for electronics experimentation and project construction— all fully diagramed, complete with parts list.

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MULTI-ELEMENT TUBES. Miller Effect—Tetrodes—Tetrode Plate Characteristic Curves—Output Signal vs. Secondary Emission—Pentodes—Suppressor Grid-Pentode Plate Characteristic Curves—Tetrode and Pentode Characteristics—A. C. Plate Resistance—Transconductance—Amplification Factor—The Pentode Voltage Amplifier—Operating Point—Cathode Bias—Cathode Bypass Capacitor—Distortion—Beam-Power Vacuum Tubes—Audio Output Stages.

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high vacuum evaporating equipment for the electronics industry . . . **SHURE ELECTRONICS, LTD.** has been established in London as a wholly owned subsidiary of **SHURE BROTHERS, INC.** . . . **GEORGE RATTRAY & CO.** has changed its name to **RAYTRON ELECTRONICS, INC.** to identify the company more closely with its established brand name.

* * *

RICHARD J. NEWMAN has been promoted to the newly created post of director of planning and development for *The Daven Company*, a member of the *General Mills* Electronics Group.

He will be responsible for the planning and development of new product lines and take charge of the expansion of existing product lines of precision wirewound resistors, metal film resistors, switches, attenuators, filters, instruments, etc.

He has been with the firm for 13 years and holds a degree in electrical engineering from Cornell.

* * *

INSTITUTE OF RADIO ENGINEERS and the American Institute of Electrical Engineers have undertaken the first steps toward consolidation which, if consumated, would result in an international organization of 150,000 engineers, scientists, educators, and industrialists.

The announcement was made jointly by Lloyd V. Berkner, president of the IRE and Warren H. Chase, president of AIEE. The resolution was first approved by the board of directors of the IRE with the AIEE board concurring. Committees were appointed from each organization to explore the possibilities.

Both organizations have headquarters in New York—the AIEE at 345 E. 47th St. and the IRE at 1 E. 79th St.

* * *

E. BRUCE McEVOY has been appointed distributor sales manager, electronic tube sales, for *Sylvania Electric Products Inc.*, succeeding Harold H. Rainier who retires January 1st.

In his new capacity, Mr. McEvoy will be responsible for the national marketing of receiving tubes, TV picture tubes, and semiconductor devices through franchised distributors. He will make his headquarters at 1740 Broadway, New York City.

He joined the firm in 1944 as one of the company's first sales representatives and has held a variety of sales positions since that time.

* * *

JAMES CARROLL has been named component sales manager of *Fisher Radio Corporation*. He was formerly audio sales manager at *Harvey Radio Company* . . . *Vector Manufacturing Company, Inc.* has named **LEONARD M. SMITH** to the post of director of sales for its Aerospace Division . . . **DR. EDWARD E.**

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ALTSHULER is the new director of research and development for *Gabriel Electronics*, Millis, Mass. . . . **LOUIS P. POLRIES** has joined *Seco Electronics Inc.* as director of research and development . . . Promotion of **CHARLES A. BLACK** to the post of general manager of the marketing services division has been announced by *Ampex Corporation* . . . *Oak Manufacturing* Co. has appointed **DR. NORRIS JOHNSTON** to the post of consultant to its engineering department . . . **ABRAHAM SCHWARTZMAN** has resigned as executive administrator of the Institute of High Fidelity Manufacturers, Inc. No successor has been named as yet . . . **WILLIAM A. WILDHACK** is the new associate director of the National Bureau of Standards. He will be responsible for coordination of NBS measurement services to science, industry, government agencies, and the states . . . **RICHARD C. KOPEREK** has been promoted to the newly created position of vice-president and treasurer of the *Hallamore Division* of the *Siegler Corporation*. He has been with the firm since 1955.

* * *

JOHN C. BARNES has been named vice-president of *Hycon Mfg. Company*. He will be in charge of several planned subsidiary developments and a number of special projects for the orderly expansion of the firm.

He was formerly with *North American Aviation's* Space and Information Systems Division where he held the dual assignment of assistant to the chief scientist and acting director of the laboratories.

Mr. Barnes is a native of Stockton, California and holds a BS in mechanical engineering. ▲

ANSWERS TO QUIZ

(Appearing on page 89)

1.	F	6.	B	11.	E
2.	L	7.	N	12.	I
3.	H	8.	M	13.	D
4.	A	9.	C	14.	K
5.	J	10.	G		

Answer to Puzzle Appearing on page 87

T	O	G	A	S	■	■	■	■	■	G	R	I	D	S
U	S	A	■	■	M	U	■	A	B	■	■	A	P	E
N	C	■	B	I	A	S	■	T	R	A	P	■	S	V
E	■	D	L	■	■	■	■	■	■	■	O	E	■	E
R	■	S	U	P	P	R	E	S	S	I	O	N	■	N
■	A	T	E	■	P	I	N	■	S	O	L	V	E	■
■	■	■	■	B	■	G	■	A	■	N	■	E	T	■
■	G	E	O	D	E	■	F	R	Y	■	D	L	O	■
■	A	M	P	L	I	F	I	C	A	T	I	O	N	■
■	D	I	E	■	■	■	■	■	■	■	O	P	S	■
V	■	T	N	■	F	A	R	A	D	■	D	E	■	C
A	■	S	E	■	I	C	■	T	U	B	E	S	■	U
L	B	■	O	■	L	■	F	■	E	N	S	■	O	R
V	I	E	■	■	■	G	A	S	■	■	■	L	A	V
E	D	I	S	O	N	■	■	■	■	P	L	A	T	E

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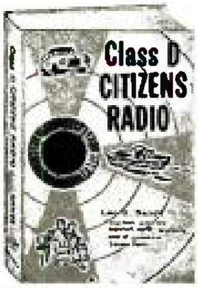

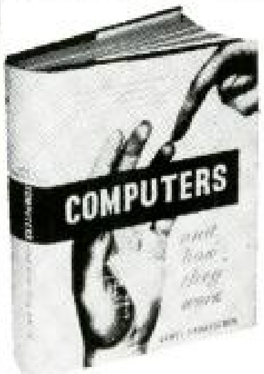

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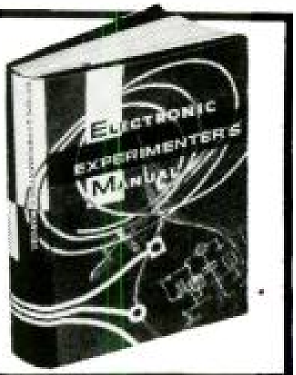

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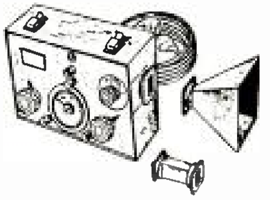

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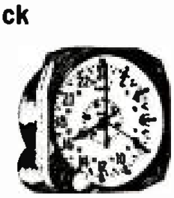

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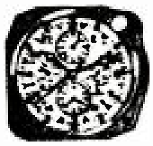

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Industrial vs TV Service

(*Continued from page* 49)

A piece of his equipment is down. The company has figured that each hour it is down they lose a potential $5000 worth of production, not to mention the fourteen girls sitting idle waiting for you to remove the bottleneck in the production line. You can't put off this customer over the phone, nor can you give him another set to use while his is being fixed. You are on the spot and the line foreman lets you know it. In his down-time report, you will probably be blamed with causing a four-hour delay even though it took fifteen minutes to repair the machine. This is one way production covers a multitude of sins. If you don't like pressure, keep out of production work. If you don't mind pressure and responsibility, production work is interesting, ever-changing, and very rewarding."

The writer. who went from service to industrial work, should know whereof he speaks. Yet another who made a similar move, Robert P. Larson, a TV transmitter engineer of Cedar Rapids, Iowa, takes a somewhat different view. One of the satisfactions in leaving TV service behind. he seems to feel, is the fact that the TV service customer has also been left behind. He remembers, "You are as a servant to your customers and are at their beck and call. This tends to raise ulcers and will either break a man or make a man."

The last two writers raise the question of temperament. From what they say, it also becomes clear that there is no such thing as one temperament for one kind of work and another temperament for the other kind. A *specific job*, in either field, must be judged on its own. Something else becomes clear: if you are contemplating a sweeping change, make sure it is backed up by calm reasoning. Don't jump simply because the grass looks greener elsewhere. You may be walking right into the very problem you are trying to run away from — like the personality problem with customer or foreman. If you want to "go industrial," a better reason might be some special, additional background that is wasted in TV work but that may uniquely qualify you for some other role. One writer, for example, had some background in chemistry. There are many positions in the electro-chemical industries that could be filled by such a person. He has filled one.

Writer J.A.R., who asks to remain anonymous, sent in his comments on the letterhead of his radio and TV service shop in the Midwest. He had his taste of industrial work in a plant "loaded with refugees from the electronics business in TV and radio repair." These men, he feels, just don't measure up to the capacity required for dealing with the public, nor do they have much business sense. They are technically qualified in the narrow sense.

Admitting that he faces many problems in consumer-product maintenance,

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he reminds us that "there is no Utopia on this earth." Among the many disadvantages involved in working for someone else, he recalls, is the fact that "labor is just as competitive as any consumer product on the market. . . . You may be one of the first to be dropped when the 'cut-back' in employees begins due to lack of business." He prefers better control over his own future than an employer allows.

Unless one takes an important viewpoint into consideration, one can become quite confused by apparent contradictions in the opinions offered by most of those who have sent in comments. The variety and ingenuity required in industrial electronics is beyond many technicians who would do better to keep to the narrow, humdrum, and uncreative work of TV service, claims one writer. The next one favors the constant growth and variety in independent work as compared to dead-end repetitiousness of an industrial job. There are other contradictions. You will make more money—or less. You will be more secure—or less.

Alan Ente of Brighton, Massachusetts, asks the questions that get us close to the heart of this matter. In the process of doing so, he touches on the subject of classifying electronics personnel, which has been highlighted in recent editorials in this publication. He wants to know first what we mean when we speak of an industrial electronics technician. We may intend a man who is working in research and development rather than production. "In this area," he notes, "an industrial electronics technician is usually a member of an engineering 'cell' consisting of three or four qualified engineers and three or four technicians, whose duty it is to fabricate designs and circuitry. Or is he an actual servicing or troubleshooting legman? Does the TV service technician have the opportunity to utilize his basic circuitry knowledge and 'troubleshooting intuition' in a production factory? Would the average service shop be able to do any industrial servicing?

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Other writers think that the future will need more and better service technicians to match expected growth in consumer electronics. Pertinent to this is a recent statement by President John L. Burns of *RCA*. Acknowledging his company's gratifying growth in industrial electronics, he has said, "Our long-range corporate projections show this consumer-entertainment field providing the largest source of income over the future." ▲

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6BY5G 6BZ6 6BZ7 6C4 6CA8 6CB6 6CD6G 6CF6 6CG7 6CG8 6CH8 6CL6 6CM6 6CM7 6CN7 6CQ8 6CR6 6CS6 6CS7 6CU5 6CU6
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MAKING MULTICONDUCTOR CABLE

By EDWARD J. KOLB

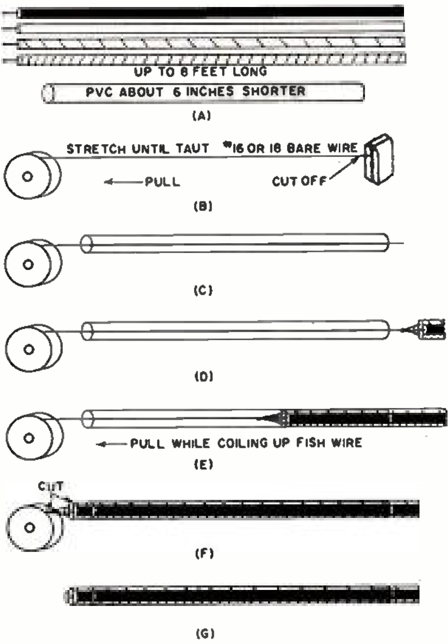
Technique for sheathing grouped conductors. Useful in testing and making measurements. Procedure is easy to follow.

TESTING and measuring procedures often require rather short cables of a specified number of conductors. While stocking multiconductor cable may be practical in production applications, research and development departments would find such stocking both wasteful and space consuming. Presented here is a method of cabling virtually any number of insulated hookup wires. This method is also applicable to single-conductor shielded wire.

The first step in making the cable is to select the correct length for your particular "run." Incidentally, this method is only practical for runs up to a maximum of 8 feet. This is usually adequate to accommodate tracking of the cable in most equipment and is certainly long enough for test set-up junctions. After selecting optimum cable length, add one foot for wastage and as a safety factor.

Cut all conductors to length plus a safety factor. Strip insulation back one inch on one end of each conductor as shown in the top drawing of Fig. 1A. Select a suitable sheathing material (such as polyvinyl chloride) of an inner diameter that will expand slightly or just barely fit when you attempt to insert the group of conductors you have prepared. Cut the sheathing about six

Fig. 1. Step-by-step technique for cabling.



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inches shorter than the length of the grouped wires, as shown in the bottom drawing of Fig. 1A.

You will now need a coil of #16 or #18 bare solid wire to use as a "fish" wire. Uncoil a length of the solid wire slightly longer than the length of the sheathing but do not cut the solid wire from its coil or spool. Clamp the free end in a vise and pull the spool until the payed-out length is straightened out. Clip off the short length used to "bite" the solid wire with the vise. See Fig. 1B.

Now thread the taut length of solid wire through the plastic sheathing as shown in Fig. 1C. Solder the solid wire to the group of prepared conductors you wish to "cable." It is important to make this cluster a smooth, neat solder junction to assure that all conductors remain intact and to minimize friction and the possibility of puncturing the sheathing. See Fig. 1D.

Carefully pull the solid wire back out of the sheath by pulling from the spool. It is easier if two men perform this step, one pulling at the spool and re-coiling the solid wire and the other slipping the sheathing over the cluster of wires. You may want to reduce friction by adding a little *Dow Corning* #4 non-conducting grease or certified pure petroleum jelly —but use either sparingly. As you pull the cluster through the sheath, re-spool the solid "leader" wire as shown in Fig. 1E.

When you have the cluster of cable completely pulled through the sheath, be sure to leave some length of the conductors extending through each end of the sheath. You are now ready to cut off the solid wire and the soldered cluster as shown in Fig. 1F.

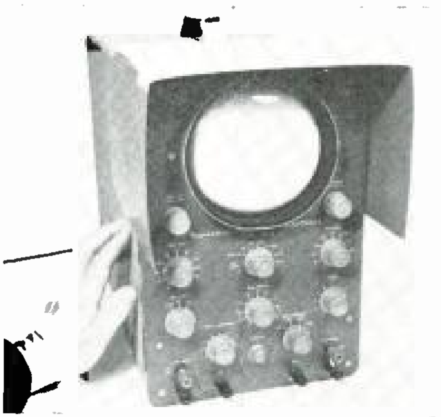
The sheathed group of insulated wires is now a cable and may be "dressed" as desired. If the sheathing is found to be too long, it may be stripped back as required and as shown in Fig. 1G. ▲

SCOPE LIGHT SHIELD

By ROBERT HERTZBERG

NORMAL room illumination often obscures patterns on the face of an oscilloscope. Visibility is much improved by the use of a simple top shield made of three pieces of thin cardboard, held together with any pressure-sensitive tape, as shown in the photograph.

An overhang of about four inches will be found sufficient for most scopes. ▲



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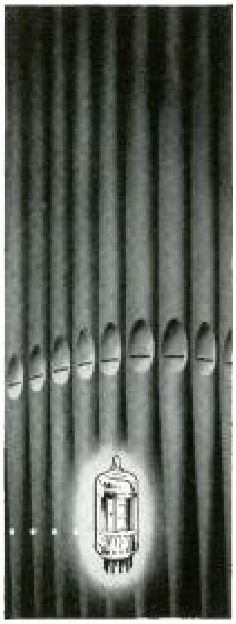



Audio Test Report

(*Continued from page* 24)

signal generator. Drift was rated at ±5 kc., with the a.f.c. off. We measured about 10-kc. drift from a cold start, occurring in about 10 minutes. A 105- to 125-volt variation in line voltage caused less than 15-kc. shift. This is one of the most stable tuners we have ever tested. The AM rejection was 40 db, also very good.

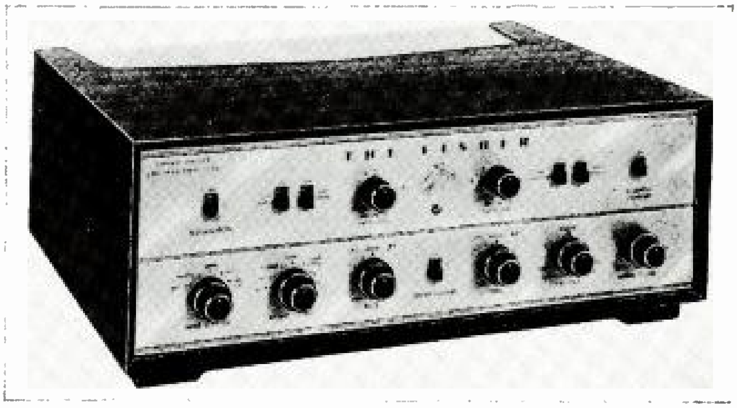
The frequency response was ±0.9 db from 20 to 20,000 cps, including the de-emphasis network and audio amplifier. The *Harman-Kardon* rating of 1 to 52,000 cps, within 0.5 db, is based on removal of the de-emphasis network, which we did not attempt to verify. Finally, at 100% modulation, we measured 2.7 volts output (3 volts rated). The output impedance of the audio amplifier is so low that a .022-μf. capacitor shunting the output only reduces the 10-kc. response by 2.5 db. In practical installations cable capacitance can be disregarded.

The handling and listening quality of the "Citation III" were excellent. The interstation muting worked perfectly, without thumps or other noises. The tuning is non-critical and actually either of the two tuning meters would suffice for this purpose. With the low drift, the a.f.c. is not at all necessary. It is fairly ineffective, reducing tuning errors by a factor of two. In use, it is not easy to tell whether the a.f.c. is on without looking at the position of the switch. The sound quality is as good as they come. The deficiencies of many lesser tuners show up glaringly when compared to the "Citation III" which has a clean, undistorted sound, velvety silent and hum-free background, and an effortless flywheel tuning system.

The "Citation III" ranks among the foremost tuners with respect to sensitivity, stability, and fidelity. It is a good value either in kit form at $149.95 or $229.95 factory-wired. A walnut cabinet is available for $29.95. ▲

Fisher X-101-B Stereo Amplifier

For copy of manufacturer's brochure, circle No. 60 *on coupon* (*page* 122).

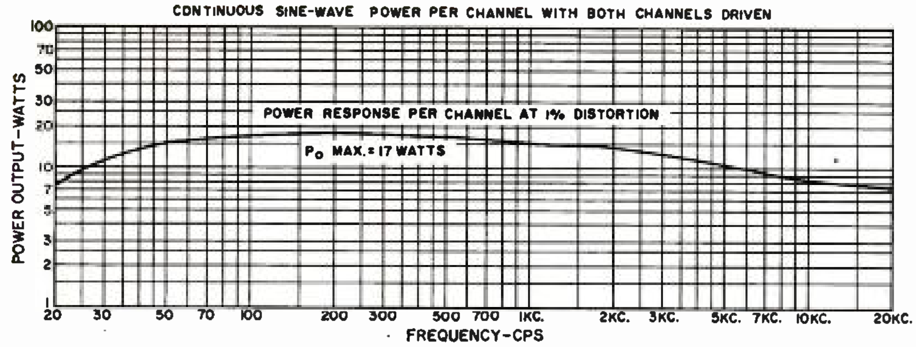


THE X-101-B is an unusually flexible integrated stereo amplifier. Selling for $189.50 without case, it offers most of the features of the company's more expensive X-1000, at a reduced power level.

The input switching provides for two magnetic cartridges; a convenience when both turntable and record changer are used. If desired, one of these can be used for a tape-head input, with a front-panel switch to change from RIAA phono to NAB tape-playback equalization. The other phono input may be used for a ceramic cartridge, with a separate pair of input jacks for that purpose. The ceramic cartridge works into a load of about 100,000 ohms, which converts its output to a velocity basis so that it can be equalized by the preamplifier. It is also attenuated to a level comparable to that of a typical magnetic phono cartridge.

In addition to the usual high-level inputs for tuners and "Aux," there is a tape-player input, to be used with tape-head preamplifiers delivering a high-level equalized output. The usual tape-monitoring facilities are included, so that a tape recorder with separate recording and playback amplifiers can be permanently connected to the amplifier and then switched into the signal path with a front-panel switch to monitor the program as it is being recorded. As a rule, this type of installation does not lend itself to modifying the tape-recorder output with tone controls or filters, since the monitoring connections customarily bypass all these amplifier functions. The *Fisher* X-101-B cleverly overcomes this difficulty with an input switching arrangement which (in the "Tape Play" position) connects the tape-recorder playback amplifier to the high-level input of the amplifier, as though it went to the "Aux" inputs. The recorder can be left connected for monitoring, yet when playing back tapes the controls of the amplifier are fully effective.

The mode-selector switch has positions for stereo, reversed-channel stereo, both inputs played through either speaker, and either input played through both speakers. Another position parallels the phono inputs for mono record reproduction. There are the usual bass



and treble tone controls, volume control with selectable loudness compensation, and stereo-balance control. Concentric with the balance control is a blend control which combines the left and right channel programs to produce anything from full stereo to full mono output.

The amplifier also has on its front panel slide switches for phase reversal on one channel, high and low cutoff filters, plus two knobs for individual adjustment of the gain of the magnetic input preamplifier. These are used to set the gain of the preamplifier to a value suitable for proper loudness compensation of the volume control, after which other external signal sources are set to provide constant volume as inputs are switched. Slight unbalances in the output levels of the two channels of a cartridge may be corrected with these controls also. Finally, a third, or center-channel speaker may be driven from the two channel outputs, and a connector supplies the mixed center channel output to an external amplifier if this is desired.

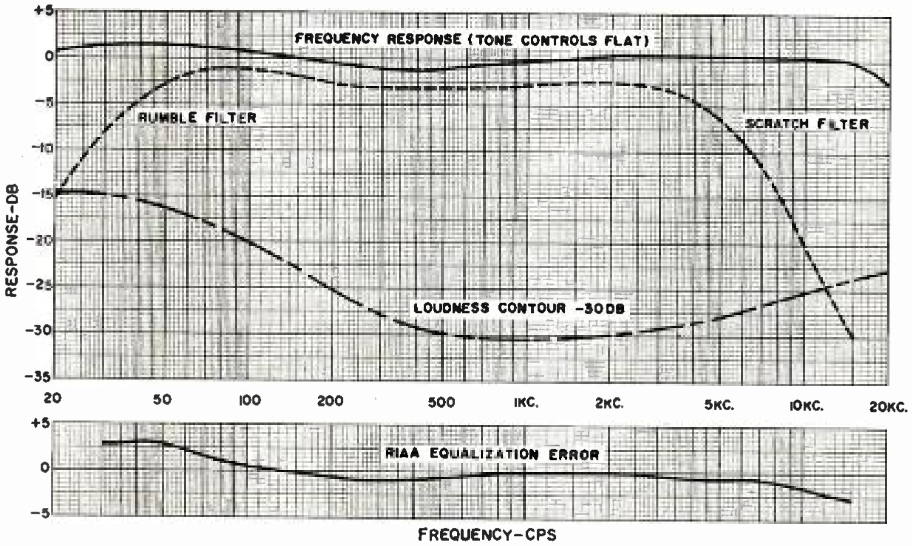
In our laboratory tests, the hum level of the amplifier proved to be extremely low, 68 db below 10 watts on phono and 87 db below 10 watts on high-level inputs. This is to a great extent due to the use of pure d.c. on the preamplifier heaters, which are in the cathode returns of the push-pull 7591 output tubes.

We understand that *Fisher* power ratings are based on driving only one channel at a time, and are IHFM music-power ratings. These are based on maintaining no-signal operating voltages within the amplifier. Our tests are run in a very different manner, which normally will result in somewhat lower power-output readings. We drive both channels simultaneously and measure power on a steady-state basis. The power-line voltage is maintained at 117 volts, but the amplifier voltages are allowed to vary as they would in normal use. Under these conditions, we measured 17 watts per channel maximum, or 34 watts total power at 1% distortion. The IHFM power bandwidth (the frequency limits at which half the mid-range power is obtained at rated distortion, in this case we used 1%) was 20 to 20,000 cps, with reference to the power output at 1000 cps. When only one channel was driven, approximately 20 watts per channel could be obtained. It is quite possible that the *Fisher* rating of 28 watts per channel (music-power output) can be developed, though we did not verify this due to the basic difference in measuring technique.

The intermodulation distortion at usual listening levels was under 0.3%, reaching 2% at 17 watts. Even at the very low frequency of 20 cps, the harmonic distortion was under 1% up to 7 watts output (per channel) which is above average performance for a moderate-priced integrated amplifier.

The sensitivity on "Phono" input measured 3 mv. and on "Aux" input measured .2 volt, both for 10-watts output. Separation on "Aux" input was found to be 35 db.

The RIAA phono equalization was within about ±3 db from 30 to 15,000 cps, and the over-all frequency response with tone controls in the indicated flat positions was ±1.5 db from 20 to 18,000 cps. The filters, as on other *Fisher* am-



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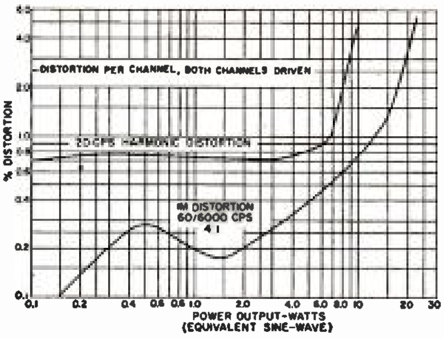

plifiers, have excellent sharp cut-off characteristics, with cutoffs at about 40 and 5000 cps, and virtually no effect on the program content, but with effective reduction of rumble or scratch. Tone-control range was normal, from +17 to −13 db at 30 cps for the bass control, and from +17 to −21 db at 15 kc. for the treble control.

Our chief criticism, admittedly a very minor one, concerns the presence of the two magnetic input level controls on the front panel. These could have been located in the rear of the amplifier, where they would have less chance of being unwittingly disturbed, and with a corresponding reduction in the number of front-panel controls. Apart from this small point, the *Fisher* X-101-B rates as one of the better stereo amplifiers in its price class. It has sufficient flexibility for practically any music system, and enough power to drive all but the lowest efficiency speaker systems. ▲

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TO STIMULATE interest in basic science, the Universal Field Foundation is sponsoring a science and math contest. The problem is to express at least 40 physical properties or physical constants, including length, time, mass, force, energy, charge, momentum, induction, reluctance, resistance, magnetic field, and current in only two basic units, so that definitions of the 40 properties in the two basic units are consistent with basic experimental evidence given in engineering handbooks and physics texts.

For example, if the two basic units chosen are Length and Time, some of the 40 definitions would be: Length = Length; Time = Time; Area = Length^2; Volume = Length^3; Velocity = Length/Time, etc.

It is possible to work out these definitions and express them in terms of high-school algebra. However, in applying the basic equations to actual problems advanced mathematics may be necessary.

The prizes are $100 for the first correct set of equations received, $50 for the second correct set, and $25 for the third correct set received. The contest closes when the three correct sets of equations have been received or on June 1, 1962. At the close of the contest, the equations will be published and the names of the winners given to newspapers.

Anyone may enter this contest except persons connected with Cornell Aeronautical Laboratory, Bell Aircraft of Buffalo, the University of Buffalo, or members of their families.

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Transmitter Tube Testing

(*Continued from page* 43)

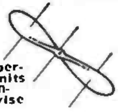
simple but there is more to this system than one would expect. Needless to say, substituting a new tube in your own transmitter requires that you should be absolutely certain that any conditions in the transmitter which might have caused the original final amplifier tube to become defective, other than normal aging, are rectified prior to placing the new tube in the socket. You could ruin a new and perhaps expensive tube.

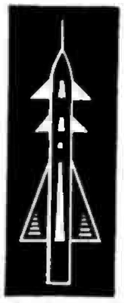
Unless the tube to be tested has short circuits existing between tube elements, the tube may be installed in a fellow ham's transmitter, providing his transmitter makes use of the same tube type and operation of the tube checked against transmitter operation with a known good tube. In order for this type of test to amount to anything conclusive, the transmitter being used for tube testing must be completely free from parasitic or other self oscillations.

Swapping tubes in the final amplifier and then checking meter readings and power output can give you a good idea as to how the tube under test is behaving. If the final amplifier does not function properly when loaded by the antenna circuit or when subjected to modulation, then the final amplifier tube being tested may definitely be defective.

One way to be sure a final amplifier tube in the transmitter is going "soft" is to make a chart of meter readings and dial settings when the transmitter is first placed in operation. This assumes that the transmitter is working properly to start with. Over a period of time, the meter readings may change somewhat or it may be noticed that the drive control must be advanced to a higher position than when the transmitter was initially operated. Perhaps the same final amplifier loading will not cause the same amount of plate current to be drawn. These and other indications may alert you to future tube failure. Remember, most of the time your transmitting tubes will fail when you wish they had not, possibly during an important contest or an enjoyable contact—not while the transmitter is off the air. Again, log all dial settings and meter readings when you first operate your transmitter and are certain that it is operating properly—whether it is a commercially manufactured unit, a kit type, or a "home-brew" transmitter.

As mentioned previously, testing of transmitting tubes by the ham is not a simple matter, but why give up hope? Performing the static or dynamic tests as outlined in this article may prove to you that the trouble with your transmitter is not your final amplifier tube but some other component—thus saving an innocent tube from the trash can. Even if you do not presently have need for testing your transmitting tubes, try testing them as described some evening when you are in an experimental mood. You may discover some things about vacuum tubes you never before realized. ▲





Don't Overload Capacitors

(*Continued from page* 37)

resistors of equal ohmic value must be connected across equal capacitors, as shown in Fig. 9. High value resistors, in the order of 470,000 ohms, should be used to limit the power dissipation. Don't forget that placing capacitors in series reduces the total capacitance. Here the equivalent capacity of two 4-μf. capacitors in series is 2 μf.

Voltage Doublers

A conventional voltage doubler is shown in Fig. 10. The purpose of this circuit is to supply a d.c. voltage approximately twice that which would be supplied by the conventional half-wave or full-wave configuration. Since this circuit is used in many television-set power supplies, proper voltage rating of capacitors C_1 and C_2 should be of interest to service technicians. On one half of the a.c. input wave, capacitor C_1 charges up to 1.414 times the r.m.s. value of the voltage across the transformer secondary. C_2 charges up to 1.414 times this value, through the second rectifier, on the negative half of the a.c. input wave. In the example shown, capacitors C_1 and C_2 will each charge up to 1.414×250 or 354 volts with the polarity as shown. The load sees two capacitors in series, each with only 354 peak volts for a total of 708 volts. Since, in most cases, these capacitors will be electrolytics, allow about a 10 per-cent safety factor. Therefore, capacitors C_1, and C_2 should each be rated for 400 volts, rather than the peak, combined output.

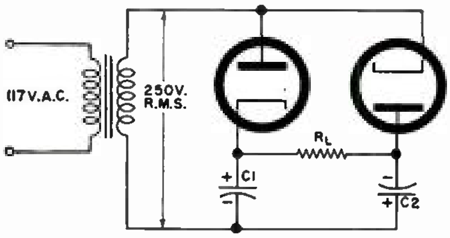


Fig. 10. Doubler filters are in series. Stepped-up output divides between them.

Special Applications

Every capacitor possesses some inductance. In conjunction with its capacitance, this value can form a parallel resonant circuit at some frequency that might be within its working range. At this frequency, the resonant capacitor behaves like a resistor, gets hot due to the high circulating currents, and can possibly destroy itself. For this reason, in most bypass applications above 1 megacycle, designers will shunt the large capacitor with a small one of about one-tenth the value of the large one. At frequencies higher than 2 megacycles, special care should be taken to select a component so constructed that it can be satisfactorily used at high frequencies. Mica, ceramic, glass, and air capacitors are usually used.

In applications where a capacitor is used in conjunction with a high-value inductance, sudden interruption of the current status within the inductor (switching on or off) can cause abnormally high voltages to be generated by the inductor. These voltages can appear across an associated capacitor and cause it to fail. The modulated circuit of Fig. 4 and the power supply circuit of Fig. 6 are examples of such usage. In most cases, the reduction of transients must be accomplished by extra protective circuitry, since the actual transient-voltage magnitudes that can be developed under all conditions are difficult to predict. The individual must use his experience and intuition in many such instances, and, when in doubt, he should add another safety factor of 50 per-cent to his capacitor voltage ratings.

When rating your capacitors, don't forget to allow for line-voltage fluctuations. Even though our power companies try to maintain their output at 117 volts, experience has shown that most electrical equipment plugged directly into the power mains will be subjected to variations from 105 to 125 volts. The high line voltage can be disastrous to a marginally rated unit. For example, the power transformer of the power supply shown in Fig. 7 is designed to produce 250 volts output with 117 volts in. Should the line voltage rise to 125 volts, the r.m.s. voltage across the secondary will increase to $125 \times 250/117$, or 267 volts. And, since capacitor C_1 in Fig. 7 is subjected to a peak voltage equal to 1.414 times this value, it must withstand 378 volts. Thus a 400-volt electrolytic may not have a sufficient safety margin. Therefore, always assume that a high line voltage exists when determining voltage ratings for capacitors.

It would be almost impossible to discuss all capacitor applications. However, most of the more common cases have been reviewed with regard to specifying voltage ratings. A little thought and conservatism in determining this value will avoid unnecessary "down time" on your electronic equipment. Eliminate a potential source of serious trouble by *not* overloading your capacitors. ▲

"I run my own service business and I'd like to buy a condenser tube."

A. C. Meter Calibration

(*Continued from page* 60)

to heat the resistor to 100°. If you wanted to read in the same temperature range while checking different voltages, the resistors would have to be chosen so that about .3 watt of power would be consumed across them. Suppose, then, that you were making a check at 12 volts. Starting out with $W=E^2/R$, we determine that you would need a resistor whose value is about 480 ohms. Current through it will be about 25 milliamperes.

A variation of the method outlined provides even better reliability but is also much slower. This is to let the resistor, with the voltage across it, heat a much larger body, and to read the temperature of the larger body. Thus with the resistor immersed in an oil or water bath and with the temperature of the entire bath stabilized, you would avoid the effects of small air currents. The bath would stabilize more homogeneously than the resistor alone. However this takes a great deal of time and would be considered only by a perfectionist. As outlined, the method will give far more precision, after calibration, than is normally expected from a conventional a.c. voltmeter.

A final word of caution: if you are going to use your a.c. voltage sources, as checked here, for later reference, remember to do this with the resistors that were used in the first step across them. When the resistors are not loading these sources, voltage output will usually go up.

True enough, the method is a painstaking one. However, what other means do you know of for such accuracy, if you work carefully, with tools that are simpler or more readily available? ▲

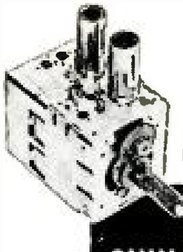
CLEANING CORRODED BATTERY CONTACTS

By HERB BROWN

BECAUSE of battery leakage, it is not uncommon for the contacts in battery holders to suffer from corrosion. This is a frequent problem with transistor radios, especially since the resistance of the impaired contact area becomes a factor with the low power-supply voltages used.

To make reliable repairs, keep on hand a dilute solution of hydrochloric acid, consisting of one part of the acid to four parts of water. You can get an ounce of the acid from your druggist. When preparing the solution, be sure to add the acid to the water, rather than the water to the acid, and avoid contact. Store in a well stoppered container made of materials that will not be etched by the solution.

First wipe the corroded contact areas clean of the deposit, scraping with a knife if necessary. Then apply the solution—a pipe cleaner is a handy applicator—and leave the solution on the metal for five minutes. Carefully wipe away the affected area, apply a heated soldering iron, and tin with a good 60/40 solder. This procedure is not only effective in restoring the contacts but provides some insurance against future corrosion. ▲



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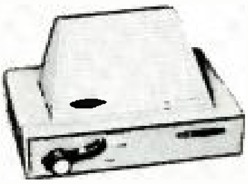

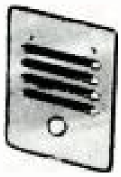

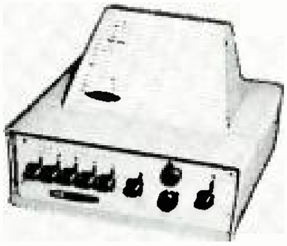

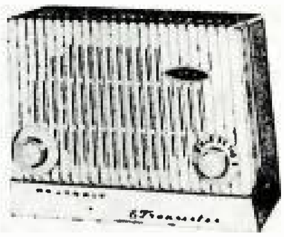

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Complete indoor & outdoor communications facilities in easy to build kit form. All-transistor master handles up to five indoor or outdoor remotes. Powerful 1 watt output and specially designed frequency response assure crisp, clear communications. Costs only 5c a month to operate!

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Battery powered. 4" x 6" PM speaker; transistor circuit; ivory & green. 3 lbs.

Kit GR-131 Radio
(less battery)........**$19.95**
GRA-131-1: Battery pack
2 lbs........**$1.10**

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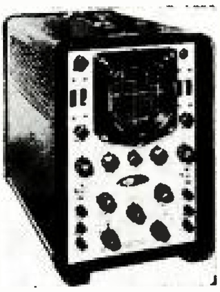
New Products and Literature for Electronics Technicians

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 122.

DOUBLE-BEAM OSCILLOSCOPE

1 **Cossor Instruments Limited** is now marketing its Model 2000 double-beam oscilloscope in the U.S. Among the features offered in this new instrument are 5-mc. bandwidth (d.c. to 5 mc.), sensitivity on both channels having maximum value of 1 mv. per cm. deflection, built-in variable time-base delay, calibrated sweep control, built-in calibration of applied input voltage, and internally generated marker-trace. This marker occurs just 50 nanoseconds after the start of the sweep and is used to give an indication of the rise-time of displayed pulses.



The scope uses a 4-inch flat-screen double-gun tube with independent brightness and focus controls for each beam.

BONDING ADHESIVE

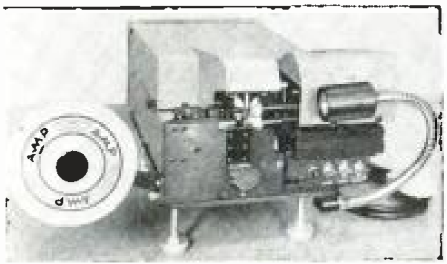
2 **Radiation Applications Incorporated** has developed a new thermosetting adhesive suitable for bonding polyolefins.

Called "Raiseal 5002," the new adhesive is especially suited to applications involving printed circuit boards requiring plastic-laminated copper. The new adhesive is effective on polyethylene surfaces without pre-treatment by flaming, corona, or chemical dips.

SPLICING MACHINE

3 **AMP Incorporated** has just introduced a new technique for splicing 26 gauge or finer stranded lead wires to 34 to 44 gauge fine magnet wire. The new product is being marked as the "Fine-Y-R Splice."

A special air-and-electric machine is used to achieve this new splice. The machine feeds a "U" shaped splice on a mounted "Mylar" tape to the applicator. The machine also features built-in stripping wheels, which are located behind the machine's crimping mechanism, which save time in stripping the fine wire.

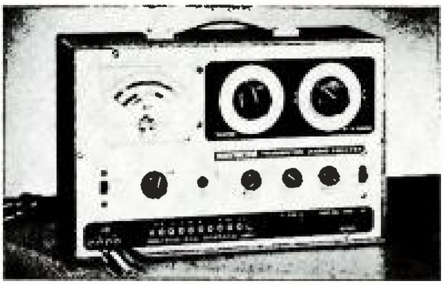


Approximately 300 splices per hour can be completed as compared to about 30 per hour with soldered splicing techniques. By actuating a foot pedal, the operator crimps the splice; the fine wire, lead wire, and "Mylar" tape are sheared; and the next splice is fed into position.

TRANSISTOR-RADIO ANALYST

4 **B&K Manufacturing Co.** is now offering a unique transistor-radio analyst designed to make the servicing of transistor sets easy and profitable.

The Model 960 features a single-point probe and includes a signal generator, power supply, v.t.v.m., milliammeter, ohmmeter, and both in-circuit and out-of-circuit transistor tester.



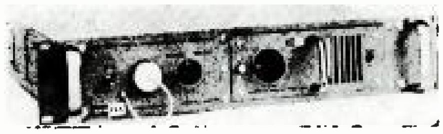
By point-to-point signal injection, it is quick and easy to troubleshoot any transistor radio, check all circuits stage-by-stage, isolate, and pinpoint the exact trouble in minutes.

The unit operates on 117 volts, 50-60 cps and is housed in a functionally designed case measuring 12⅛" x 7¾" x 4⅞".

DIFFERENTIAL D.C. PREAMP

5 **Kin Tel Division** has announced the development of a new differential d.c. preamplifier—floating and narrow band—for general use.

The Model 459 C/N, with the gain set at —100, extends the range of the firm's digital voltmeters to 1 microvolt d.c. and provides stable, accurate amplification of low-level input signals in the presence of high common mode noise and hum.



Common mode rejection is 180 db for d.c. and 130 db for 60 cps with up to 1000 ohms unbalance in either signal lead. The input is completely isolated from both output and chassis ground may be floated up to ± 300 volts with respect to ground.

FLOW CONTROL ALARM

6 **Terriss-Consolidated Industries** has developed a new alarm system for liquid flow control. Designed primarily for use on automatic filling machines, the new unit is a unique device for sensing slowdown in pressure lines whether it be syrup, liquid, or water. Any failure in the supply immediately actuates an alarm bell which alerts the operator.

Sanitary construction is featured throughout with contact surfaces of stainless steel. The internal diaphragm is of durable neoprene.

BROADBAND SPECTRUM ANALYZER

7 **The Electronics Group, General Mills, Inc.** has designed a broadband spectrum analyzer to measure the power and coverage of radio transmitter jamming signals. This device uses a simple, precise technique for analyzing the average r.f. power level and frequency distribution, requires low power for operation, is light in weight, and supplies data for evaluation at high speed. It can be used as airborne equipment or as ground-support equipment.

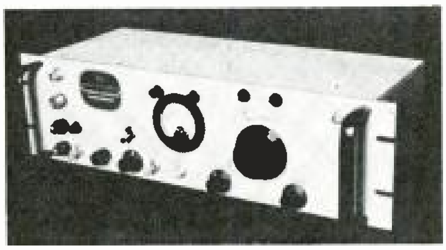


CHART RECORDERS

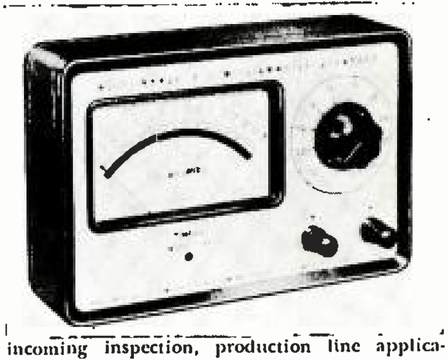
8 **Rustrak Instrument Company** has added two new chart recorders to its line of miniature, automatic recording instruments: the 5-ampere current recorder and the Model 113 a.c. power tester and recorder (photo).

The current recorder is designed for continuous operation in reading and recording a.c. current. The instrument uses no ink or heated stylus and records by a dry writing process using pressure-sensitive paper, making it suitable for use under any temperatures, humidities, and altitudes.

The Model 113 is a rugged, portable instrument for testing a.c. voltage and current conditions. A selector switch on the front panel selects three voltage ranges and four current ranges. Through an exclusive "read and write" feature, the recorder may be used as a direct-reading panel meter or as a recorder.

MULTIRANGE STANDARDS

9 **Simpson Electric Company** has just introduced a new line of laboratory standards for general industrial laboratory testing, plant incoming inspection, production line applications, and for school laboratories.

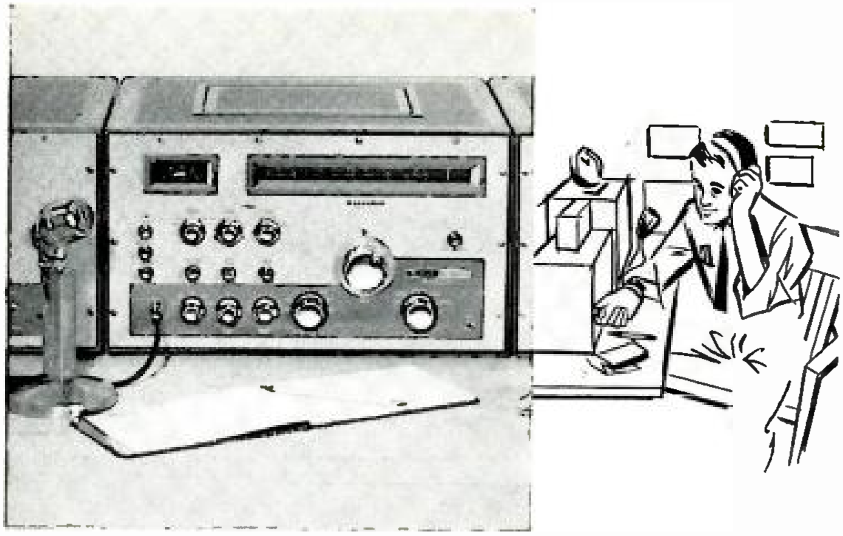


The Model 1700 d.c. voltmeter and the Model 1702 d.c. milliammeter (pictured) feature the firm's self-shielding deep core construction with spring-mounted sapphire jewels and hardened steel pivots. The meter is temperature compensated from 15 to 35 degrees C. Hand-stepped, hand-drawn white enamel dial with mirror segment assures accuracy over the entire scale arc.

A data sheet giving complete specifications on this new line is available on request.

DUAL-GUN CRT

10 **Electronic Tube and Instrument Division of General Atronics Corp.** is now offering a new 12-inch dual-gun CRT which is said to provide



WORLD-WIDE REACH!
SHORT WAVE RECEIVER

Covers 550 kc to 30 mc in four bands. Illuminated 7" slide-rule dial & meter. Versatile controls for top reception. "Velvet touch" tuning. Easy circuit board assembly. Beige & aqua color. 9 lbs.

Kit GR-91...no money down, $5 mo.........**$39.95**

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SSB TRANSMITTER IN KIT FORM!

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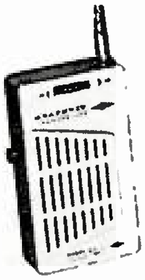
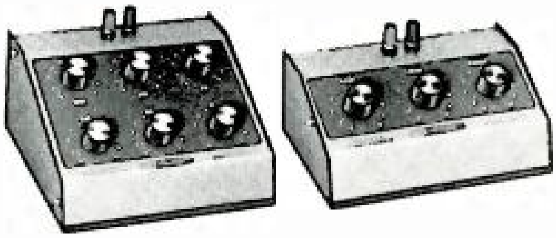
Kit HX-10 SSB TRANSMITTER...92 lbs...no money down, as low as $22 mo.**$334.95**





NEW CITIZEN'S BAND TRANSCEIVERS

New high-efficiency transmitter. 3-crystal controlled transmitting channels; single crystal or variable receiver tuning. Adjustable squelch, automatic noise limiter. Press-to-talk mic. Signal meter. 13 lbs.

Kit GW-11 . . . specify AC or DC . . .
no money down, $7 mo....................ea. **$66.45**

POCKET SIZE
"WALKIE TALKIE"

4-transistor; crystal-controlled. Range 1 mile. Easy circuit board assembly. 2 lbs.

Kit GW-31 ea. **$24.95**

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Provide precision resistor values from 1 ohm to 999,999 ohms in one ohm steps, at ½ of 1% accuracy . . . capacitor values from 100 mmfd to 0.111 mfd in 100 mmf steps.

Kit IN-11...6 decade resistance kit...4 lbs....
no money down, $5 mo..........................**$24.95**
Kit IN-21...3 decade capacitor kit...3 lbs..........**$17.95**

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ITEM	MODEL NO.	PRICE

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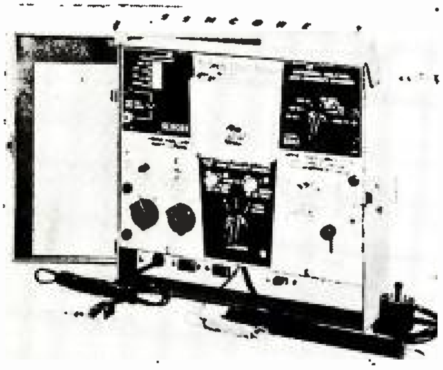
This Christmas Give a Heathgift . . . from the World's Shopping Center for Electronic Kits tracking accuracy over a 10-inch-diameter useful area with a maximum error of 0.070 inch. With additional electrodes providing further electrical correction, accuracy can be improved to approximately .050 inch maximum.

The new Type M1030 is one of a family of six 12-inch tubes developed by the firm in recent months to provide new radar tracking and fire control efficiency.

TV SWEEP CIRCUIT ANALYZER

11 Sencore, Inc. has developed a new TV sweep circuit analyzer which is being marketed as the Model SS117.

Designed to speed the pinpointing of TV sweep, sync. and high-voltage troubles, the unit permits all important checks to be made from the top of the TV chassis without removal from the cabinet. The SS117 checks horizontal oscillator, horizontal output, horizontal deflection yoke, horizontal output transformer, vertical deflection yoke, and second anode voltage.



The instrument features a large 0-300 µa. meter for minimum circuit loading, an all-steel carrying case with full mirror in the removable cover, and two 117-volt a.c. outlets in the cable compartment.

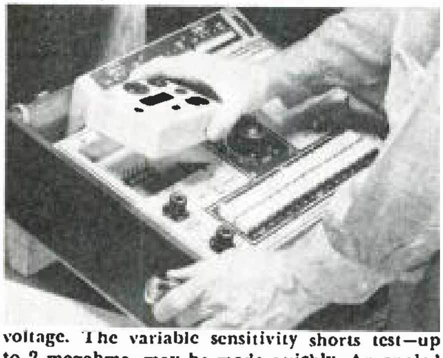
FORCE WASHERS

12 Lockheed Electronics Company has added a temperature-compensated force washer to its transducer line. Actually miniature load cells, the new units approximate the shape of regular bolt washers, temperature-compensated for temperatures 50 to 250 degrees F. They come in standard bolt sizes ranging from 3/16" to 1" in diameter. The loads for these diameters range from 5000 to 35,000 pounds, depending on bolt diameter selected.

Accuracies of better than ± 1% of full-scale sensitivity are held for linearity, repeatability, and hysteresis.

NEW TUBE TESTERS

13 Jackson Electrical Instrument Co. is now offering improved versions of two of its tube testers. The Model 648S (photo) is designed especially for service technicians and features push-button sequence switching. The unit features 23 separate heater voltages from .75 to line voltage. The variable sensitivity shorts test—up to 2 megohms—may be made quickly. An angled view zig-zag roll chart and an automatic line-voltage indicator are standard.



The second unit, Model 658A, is primarily for industrial, laboratory, and engineering applications. This model will make all tests on new and old type tubes including: heater continuity, heater current, rectifier tests, dynamic "eye" tube tests, and grid leakage.

TRANSLATOR/DISPLAY UNIT

14 United Aircraft Corp.'s Norden Division has developed a portable, transistorized translator and decimal display unit to aid users of analogue-to-digital converters.

The TADD-4-BCD unit gives an immediate digital readout of the encoder in a system—a decimal equivalent of the information which the encoder is providing at any given moment. The unit translates binary coded decimal information into the decimal equivalent.

The unit is completely transistorized and contains no relays. According to the company, this makes the TADD at least 1000 times faster in responding to electrical impulses.

TANTALUM FEEDTHROUGHS

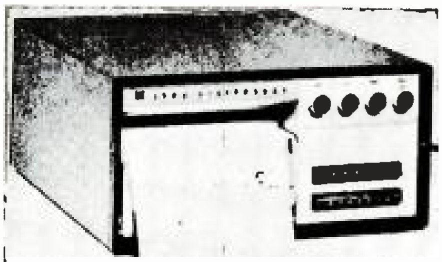
15 Fansteel Metallurgical Corp.'s Rectifier-Capacitor Division has announced the availability of a new solid-tantalum, hermetically sealed feedthrough capacitor for chassis wall mounting. These capacitors carry low-voltage d.c. circuit leads through sheet metal portions of electronic chassis to effectively bypass r.f. noise.

Designated Type STAF, ratings range from 4.7 to 1 µf. for use on 6 to 35 working volts maximum under 8 to 46 maximum surge volts.

RECORDING OSCILLOGRAPH

16 Minneapolis-Honeywell's Heiland Division is now offering a 24-channel, direct-recording oscillograph designed for rack mounting in industrial, scientific, and aerospace instrumentation systems.

The Model 1508 "Visicorder" can handle 24 channels on 8" wide paper, with each channel capable of recording individual static or dynamic phenomena at frequencies from d.c. to 5000 cps. All operating controls are on the front panel of the instrument and any of 12 recording speeds may be selected before or during recording by means of push-button controls. Deflection of 8" peak-to-peak is possible and traces are recorded at writing speeds well in excess of 50,000 ips.



COAXIAL DUPLEXER

17 Microwave Associates, Inc. has recently introduced a compact, all-solid-state coaxial duplexer for use in microwave applications at the L-band. Designed to provide light weight with all-solid-state reliability and ruggedness, the MA-3477 is for applications which require 5 to 10% bandwidth in the 1000-1400 mc. region.

Transmitter-receiver isolation at rated power, irrespective of antenna mismatch, is 40 db minimum. The MA-3477 handles 1.5 kw. peak power and up to 60 watts c.w.

RADIATION DEMONSTRATOR

18 Cenco Instruments Corporation is now marketing a new portable, lightweight, fully transistorized radiation detection instrument for industry.

Called the "Radioactivity Demonstrator," the unit provides both visible and audible indication of radiation and can be used to demonstrate the statistical nature of the frequency of particle emission from radioactive material, the dependency of the detected radiation on the distance from the source, and the absorption of different types of radiation by various materials.

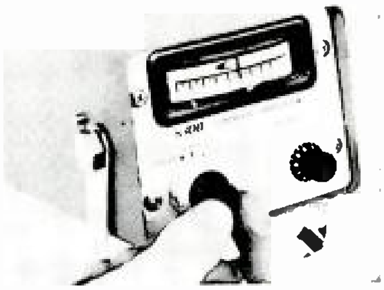
Two beta-gamma sources and a shielded Geiger-

Mueller probe with six feet of coaxial cable are a part of the equipment, along with a complete experiment kit which includes a calibrated bench and lead and aluminum absorbers.

CARRIER AMPLIFIER

19 Crescent Engineering & Research Co. has developed a transistorized, single-channel carrier amplifier which is designed for use with all types of electromechanical a.c. transducers, including differential transformers and other carrier-demodulator applications.

The model is currently available in two frequencies: 3 and 10 kc. Line regulation is better than 0.1% and the temperature coefficient less than 0.01% per degree F. Other carrier frequencies will be available later.



The instrument operates from 60-cycle, 117-volt power sources and provides a carrier frequency, regulated to within 1%, for transducer operation. The output is amplified and demodulated by a phase-sensitive demodulator. The d.c. output is indicated on a panel meter.

R.F. SIGNAL GENERATOR

20 Lafayette Radio Electronics Corporation is now offering a new low-cost r.f. signal generator as the Model TE-20.

Completely factory wired and calibrated, the unit is especially suited for i.f.-r.f. alignment, audio signal tracing, TV linearity checks, etc. Included are a 4½" etched steel circuit dial (vernier tuned), fundamental frequency output of 120 kc. to 130 mc. in six bands plus a calibrated harmonic band of 130 to 260 mc., a built-in 400-cps audio oscillator with adjustable output to 8 volts, and a continuously variable r.f. attenuator and "high-low" r.f. outputs. Frequency accuracy is ± 5%.

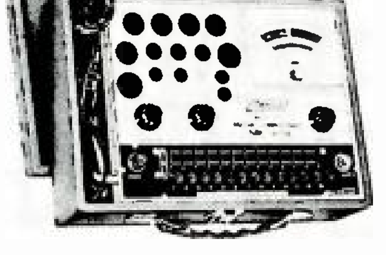
ELECTRIC SOLDERING POT

21 **Electric Soldering Iron Co., Inc.** is currently marketing a new electric soldering pot which is especially suited for the simultaneous stripping and tinning of plastic insulated wire and leads on small parts.

The Model 875 is rated at 150 watts and 1000 degrees. Solder capacity is ¾ pound and the unit measures ⅞" dia. x ¼" to 3½" deep inside. The unit can be furnished with an adjustable thermostat for selecting and maintaining best operating temperatures for precision production.

DYNAMIC TUBE TESTER

22 Mercury Electronics Corp. has added the Model 1000 mutual conductance tube tester to its line of equipment for the service profession.



The tester can accommodate all the new tube types including nuvistors, compactrons, 10-pin tubes, and novars. The unit has a range of operation which includes tests for true dynamic mutual conductance, tests for shorts and leakage between tube elements, tests for gas and grid emission with a sensitivity of over 100 megohms, as well as testing picture tubes. Lever switches provide complete versatility in accommodating all pin arrangements.

SILICON RECTIFIER LINE

23 Amperex Electronic **Corporation** has entered the heavy-duty silicon rectifier field with two double-diffused 20-ampere silicon power rectifiers which have been mounted in 50-ampere cases for added reliability and durability.

The Types BYZ14 and BYY15 are both designed for use in industrial power supplies, battery chargers, induction and dielectric heating equipment, and broadcast transmitters. They can also be used in series-parallel arrangements for heavy-duty applications.

PHOTOELECTRIC CONTROL UNITS

24 Melpar, Inc. has introduced a full line of transistorized photoelectric control units for use in automatic control systems.

The units contain a power supply, amplifier, and control relay in one compact aluminum case. A stepdown transformer and voltage-doubler rectifier provide the electrical requirements of the corresponding photoelectric readers. The multi-stage transistorized d.c.-coupled amplifier receives the photocell input and operates the output relay when sufficient input voltage or current change occurs.

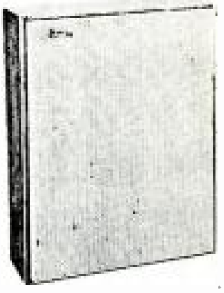
FERRITE-BEAD CHOKES

25 National Radio **Company** has announced the development of a ferrite-bead choke for use at high-frequency and very-high-frequency ranges. At power supply and audio frequencies, the new units present no more impedance to these circuits than an ordinary hookup lead. At frequencies in the range above 10 mc., the choke exhibits a substantially constant a.c. resistance and impedance, making it useful for isolating high-frequency signals from the power supply and a.f. circuits.

HI-FI—AUDIO PRODUCTS

SLIM-LINE SPEAKER KIT

26 Fisher **Radio Corporation** is introducing a slim-line speaker in kit form as its Model KS-1. Designed to permit complete assembly, even by an unskilled person, in less than an hour, the kit includes a three-way speaker system with crossover networks, finished-sanded birch or walnut cabinet, grille cloth, AcousticGlas padding, and stage-by-stage, easy-to-follow instructions.



The speaker is only 5¾" deep and lends itself to virtually any type of installation. Speakers include a 10" woofer, 5" mid-range, and 3" super tweeter. All speakers are balanced at the factory for smoothness of response. Crossovers are at 1400 and 5000 cps. Impedance is 8 ohms. The enclosure measures 24"x 18"x 5¾". The cabinet is available factory assembled if desired.

STEREO TEST RECORD

27 **CBS Laboratories** has introduced a new stereophonic frequency test record developed especially for designers of phono equipment and hi-fi enthusiasts.

According to the company, with the new record it is possible to obtain frequency response and channel separation on an automatic curve tracer in a fraction of the time it takes to do it manually. Spot frequency bands are also provided for manual tracing. The record permits checking for proper channel orientation and separation and estimating of the frequency range of stereo equipment. In addition, the record provides a means for evaluating tonearm resonance, compliance, wavelength loss, and stylus wear.

TURNTABLE-CHANGER

28 **Electro-Acoustic Products Co.** is now offering a professional turntable-changer as its 7000 Series. Featuring four speeds, rumble and wow specifications exceed NAB standards. The mechanism is jam-proof with a 7-second change cycle at all turntable speeds. Single-knob operation is featured with all controls concentric at convenient position away from the tonearm. A muting switch eliminates noise during the change cycle. The four-pole, four-coil induction motor is forced air-cooled and dynamically balanced. Turntable speed is accurate to ±1%. Tracking pressure is 2.5 to 3 grams. The unit comes with a special high-compliance pickup equipped with diamond stylus.

STEREO SPEAKER SYSTEM

29 **R. T. Bozak Manufacturing Co.** has introduced a new speaker system which is especially designed to provide maximum stereo reproduction quality. Known as "Symphony No. 1," Model B-4000, the new system is said to overcome the difficulties encountered in attempting to reproduce music stereophonically in large rooms.

Through a new speaker configuration employing eight tweeters in a column, a special midrange unit, and two woofers, highs are distributed throughout the room in a horizontal plane while the highs are concentrated in a narrow vertical beam at the listening levels.

The system is housed in a cabinet designed to blend with contemporary, traditional, or Far Eastern decor. Measuring 44" high x 27¾" wide x 16" deep, the cabinet is available in walnut, mahogany, ebony, or fruitwood finishes. Frequency response is 35-20,000 cps with crossover points at 200 and 1500 cycles. Impedance is 8 ohms. Amplifier power of not less than 30 watts per channel is recommended by the manufacturer.

STEREO TAPE RECORDER

30 **General Magnetics & Electronics Inc.** is offering a self-contained, four-track stereo recorder in its "Gemark" line of tape recorders.

Frequency response is 50-15,000 cps at 7.5 ips and 50-10,000 cps at 3.75 ips. Signal-to-noise ratio is better than 48 db while wow and flutter is less than .25% rms. The unit features four-track stereo and mono record and play; sound-with-sound control for recording on one channel while listening on the other; a built-in stereo speaker system; 20 watts stereo power with two dual record-playback preamps and push-pull output stages for full-power monitoring while recording; facilities for recording and playing multiplex; and separate volume and equalization controls for each channel.

The Model 420 recorder is UL-approved and is all-American made.

COMPONENT CABINETS

31 **University Loudspeakers, Inc.** is currently introducing a line of credenza component cabinets featuring furniture-styled doors that can be removed and replaced with differently styled doors in seconds.

The cabinets and doors are available in the following furniture styles and finishes: Italian Provincial, French Provincial, Swedish Modern, and Colonial in walnut, oiled walnut, and fruitwood. Over-all dimensions are 36" wide x 29¼" high x 19" deep. Interior dimensions of the tuner-amplifier compartment are 24½" x 9¼" x 15½" while the record-changer section is 18⅛" x 12½" x 15½".

E-V ELECTRIC ORGAN

32 **Electro-Voice, Inc.** is in production on a two-manual electric organ which uses twelve tone generators each with two stationary stators with engraved complex waveforms for each note and each voice. A synchronous motor rotates a scanner having radial lines corresponding to the number of octaves on the stator. The relative movement between the stator and the scanner produces the sound by a variable capacitance change. Each generator scanner operates at a fixed speed which determines the note of the scale and all related octaves.

The Model D-20 consoles are being offered in three styles and a variety of finishes. Console dimensions are 49¾" wide by 41" high by 30½" deep.

"STEREO CONVERTER"

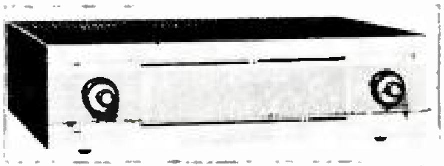
33 **Trans-National Electronics, Inc.** is handling the U.S. distribution of a Japanese-made "stereo converter"—a non-electronic device known as the "Pioneer Stereoscope."

Basically the unit is like a conventional tone-arm with stereo or mono sound transmitted through a pair of plastic tubes to earpieces. In appearance it resembles a physician's stethoscope and its operating principle is similar to stethoscopes where sound is amplified by a diaphragm. The left sound channel comes through the left earpiece, while the right channel picks up music directed to the right earpiece. For exact stereo balance the volume may be controlled independently by mixing either channel. The device is designed to be used with any type of motor-driven turntable.

MULTIPLEX TUNER

34 **Allied Radio Corporation** is now offering a stereo FM-AM tuner with built-in multiplex adapter circuitry as its "Knight-Kit" Model KF-90.

The multiplex section of the unit is designed to reproduce the full dynamic range of stereo FM broadcasts without loss of response. In addition, a front panel "dimension" control allows the listener to vary channel separation during FM stereo broadcasts. Dynamic sideband regulation reduces FM distortion stemming from overmodulation at the station or weak signals in fringe areas. Automatic frequency control is provided for lock-in tuning. Separate "magic-eye" tuning indicators for both FM and AM close to a slit when a station is perfectly tuned.



SPINET ORGAN KIT

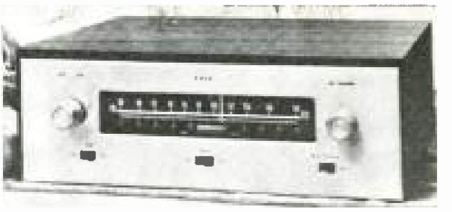
35 **Schober Organ Corporation** has just made available an electronic organ with 88 keys and 13 pedals and weighing less than 100 pounds. The spinet model features a new design which can be assembled in fifty hours. Printed circuits offer a "pre-fabricated" assembly which eliminates tedious wiring. The instruction manuals for assembly are clear and detailed with each small unit and step perfectly described and explained.

The company also has "Concert" and "Consolette" models available in its build-it-yourself organ line.

MULTIPLEX TUNER

36 **Eric Electronics Corporation** has added the Model 3457MX FM stereo tuner to its line of audio equipment.

A Foster-Seely discriminator circuit assures low noise levels and minimum distortion. Sensitivity is less than 1 μv. at 20 db quieting, producing low interstation levels. Response is 20 to 20,000 cps and an automatic frequency control, plus defeat, prevents station drift.



G-E Compactron tubes are employed and the unit features the firm's exclusive "Stereo Announcer" which automatically lights up when FM stereo is being broadcast.

The unit is housed in walnut or metal enclosures with satin-gold front panels. Dimensions are 13-3/4" x 4-5/16" x 8".

CB-HAM-COMMUNICATIONS

HAND-HELD CB UNIT

37 **Electronic Instrument Co. Inc.** is now in production on a new, completely portable hand-held CB transceiver which can be operated without a license.

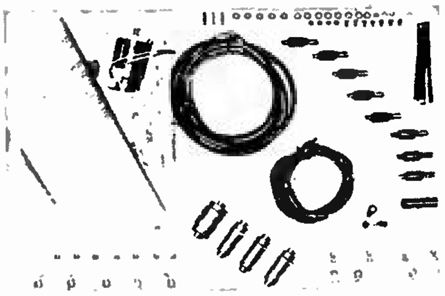
The Model 740 weighs only 19 ounces including battery and measures 7⅛" x 2⅝" x 1⅝". It comes complete with a nickel-cadmium recharge-able battery and charger.

Transmitter and receiver are both crystal-controlled. A press-to-talk button operates the unit. The receiver circuit uses 7 transistors and 1 diode while the transmitter circuit uses 2 transistors. The battery supplied is capable of providing 10-12 hours of intermittent use on one charge and it can be recharged up to 500 times. The charger operates from any 117-volt line output and when plugged into the Model 740 will charge the battery in 15-20 hours.

Communicating range between two 740's is up to 10 miles under most favorable conditions and under average conditions about 1½ miles. The 740 incorporates a 41" telescoping antenna, a long-stroke push-to-talk switch, and volume control with "on-off" switch. A 2¼" PM speaker serves both as speaker and microphone. The unit is available in kit and wired versions.

NOISE-SUPPRESSION KIT

38 **E. F. Johnson Company** is now offering a complete ignition suppression kit for the suppression of ignition noise on boats or motor vehicles equipped with two-way radio units. The kit includes an illustrated booklet with detailed instructions and all necessary hardware and fittings for complete installation.



The kit supplies effective noise suppression by shielding the wires carrying noise signals, by a resistor-capacitor combination on the generator and distributor to suppress arcs and, for the sparkplugs, resistors are inserted to block the transfer of r.f. energy back to the car wiring. Shielded cable is also used extensively in the noise suppression kit to suppress radiation from the cable contained within the shield.

TRANSISTOR CB UNIT

39 **Cadre Industries Corporation** has added a completely transistorized transceiver to its line of CB equipment. This compact 5-watt unit is designed either for home-base or long-range use.

Designated the Model 500, the unit is equipped with squelch and automatic noise limiter which makes reception easily intelligible above engine noise of automobile, boat, or plane. Range is 10-15 miles over land and 20 miles over water. The cabinet measures 12" x 3" x 6" and weighs less than 6 pounds.

Operating in the 27-mc. range, the "500" has five receiving channels and five transmitting channels. The receiver also tunes all 23 Citizens Band channels. The circuit uses 15 transistors and 7 diodes.

HAM RADIO KIT LINE

40 **World Radio Laboratories** is currently introducing a new series of "Comet Kits" designed and priced for the radio amateur. There are eight items in the current line with more items to be added in the future.

The "TechCeiver-6" shown in the photo is one of the smallest 6-meter transceivers commercially available. It includes a superhet receiver tunable 48-54 mc., push-to-talk relay, built-in automatic noise limiter, tuning and power indicators. Output with plate modulation is over 1 watt. Separate power supplies are available for fixed or mobile operation. The TC-6 uses standard 8-mc. crystals.

Other items in the line are an operations desk, a "Q" multiplier, antenna tuner, vertical antenna, a duo-doublet antenna, and an "on-the-air" box for ham shacks.

"UNIVERSAL ANTENNA"

41 **Mark Products Company** is now marketing a unity-gain, half-wave, end-fed vertical antenna designed for operation between 144 and 180 mc. to a power level up to 250 watts.

Designated as the J-150, the new unit features a quarter-wave matching and isolating stub which eliminates mast coupling and the need for ground radials. The base has a 1¼" I.P.S. female pipe thread and will mount on standard steel or aluminum rigid electrical conduit or water pipe. The user can cut the J-150 to the desired frequency by selecting the proper lengths from the cutting chart, which is supplied, cutting the two aluminum elements accordingly with a hacksaw or tube cutter.

TUNNEL DIPPER

42 **Heath Company** is currently introducing a unique grid-dip meter which features an entirely new concept in circuit design. Known as the "Tunnel Dipper," the instrument uses transistors with a tunnel diode as an oscillator.

Solid-state circuitry with its low power requirements permits using a single flashlight cell for power. New styling features convenient arrangement of control, meter, and coil for simple, easy operation. The tuning dial and coils are color-matched for easy identification and to prevent errors caused by reading wrong scales. The coils are epoxy coated for durability and stability and the protective cover supplied for dial and meter has built-in storage space for coils.

The instrument, which covers the frequency range of 2.7 to 270 and measures only 4" x 3" x 5½", can be used to find resonant frequencies of tuned circuits, to identify parasitics, check antennas for resonance, tune traps and filters, as a emergency signal generator, or as a sensitive tuned r.f. detector.

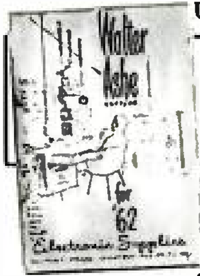
MANUFACTURERS' LITERATURE

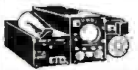
TIME/FREQUENCY METER

43 **General Radio Company** has issued a six-page data sheet covering its Type 1130A digital time and frequency meter. Included in this publication are complete mechanical and electrical specifications on the device along with application data and information of interest to design engineers.

PLATE-ASSEMBLY REPLACEMENTS

44 Aerovox Corporation's Distributor Division has issued a new easy-to-read and handy-to-use plate assembly (Continued on page 120)





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**

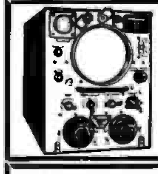
Receiver-Indicator as above, BRAND NEW **$88.50**

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! Supplied with 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. BRAND NEW..........$49.50

12-Volt Inverter Power Supply, Like New...P.U.R.

Shock Mount for above..........$2.95

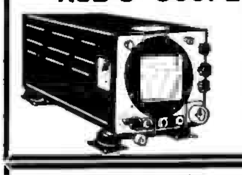
Circuit diagram and connecting plugs available.

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!

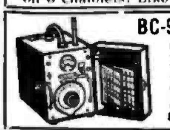
OUR LOW PRICE... $15.95

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. BRAND NEW, complete with antenna. Manual and original calibration charts included.

OUR LOW PRICE.......... **$10.88**

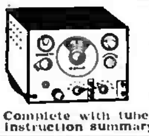
BC-221 FREQUENCY METER

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

RA-133 original A.C. power supply made for Govt. For use with BC-221. Wired and tested **$18.95**

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**

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**

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

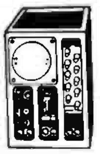
CD-307A Cords, with PL55 plug and JK26 Jack .99

Earphone Cushions for above—pair.......... .50

SCR-625 MINE DETECTOR

Complete portable outfit in original packing, with all accessories. Brand New **$27.50**

BC-603 FM RECEIVER



20 TO 27.9 MC.

Like new **$16.95**

BRAND NEW **$22.50**

10-channel, pushbutton or continuous tuning. Complete with speaker, squelch, and ten tubes: 3-6AC7, 1-6J5, 2-12SG7, 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 Rcvr 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 Rcvr 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 RCVR CONVERTED FOR ANY FREQ.—30 TO 50 MC.

BRAND NEW! Checked out, perfect working condition, ready for operation. Specify Frequency desired (between 30-50 Mc) when ordering. **$29.50**

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

BC-605 INTERPHONE AMPLIFIER for above. BRAND NEW..........**Each $4.95**

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. Like new.......... **$29.50**

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.

Shipping weight 25 lbs. **SPECIAL!**..... **$19.50**

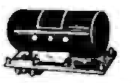
PE-101C Dynamotor, 12/24V input..........	$7.95
UHF Antenna Assembly..........	2.45
Complete Set of 10 Plugs..........	5.50
Control Box..........	2.25

SPECIAL "PACKAGE" OFFER:

BC-645 Transceiver, Dynamotor and all accessories above. COMPLETE. BRAND NEW, While Stocks Last.......... **$29.50**

MOBILE-MARINE DYNAMOTOR

Model DM35



Input 12V DC. Output: 625 V DC @ 225 Ma, for press-to-talk intermittent operation. Shpg. wt. 14 lbs.

OUR LOW PRICE. BRAND NEW....... **$9.45**

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

SMALL DC MOTORS

All 27.5 DC Input

Overall 3¾″ x 1¼″ Dia.

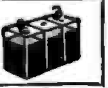
5069790 100 RPM Delco	$3.95
5BA10AJ52 145 RPM GE	4.25
5068750 160 RPM Delco	3.95
5072735 200 RPM Delco	3.95
5067127 250 RPM GE	4.25
5069800 575 RPM Delco	3.75
5BA10FS226A 575 RPM GE	3.75

2 VOLT BATTERY "PACKAGE"

1—2V. 20 Amp. Hr. Willard Storage Battery, Model #20-2, 3″ x 4″ x 5½″ 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

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.

G & G RADIO SUPPLY CO.

Telephone: CO 7-4605

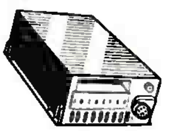
Mail Order
51 Vesey St.
New York 7, N. Y.

Retail Sales
75-77 Leonard St.
New York 13, N. Y.

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.

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.

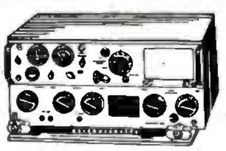
ARC-3 TRANSMITTER

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..........$22.50

ARC-3 PUSHBUTTON CONTROL BOX..........$5.95

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**

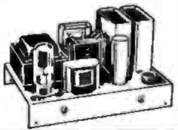
T19 TRANSMITTER ¾ m.c. complete with all tubes and crystal. Exc. Used **$9.95**

BC-456 Modulator ....**USED 3.45 NEW 5.95**

MD7 Modulator, Like New..........$9.95

ALL ACCESSORIES AVAILABLE FOR ABOVE

UNIVERSAL POWER SUPPLY KIT



For All Command Xmitters and others requiring:

INPUT: 117V 60 cycles AC.

OUTPUT: 450V DC @ 150 Ma. 24V DC @ 2 Amps.

Carefully designed, using top quality components. A really substantial, good-looking unit.

BARGAIN PRICED AT **$29.50**

GAS-ENGINE DRIVEN GENERATOR

Navy Model EF-8 rated at ½ HP, 2250 RPM. Supplies 500 VDC @ .085 Amp and 12.6 VDC @ 2 Amp. Overall length 21⅝″. height 16″, width 10-⅜″. Shpg wt 130 lbs. Complete with 50-ft generator cable. VERY SPECIAL, LIKE NEW .... **$69.50** FOB Ogden, Utah

LIMITED QUANTITY SPECIALS!

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
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PRINTED CIRCUITS, free catalog lists hundreds of circuits. Cloud "9" Engineering, Brookdale, California.

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replacement guide which provides service technicians with a complete and up-to-date listing of available units.

The guide includes the manufacturer's part number, the identification printed on the part, and the Aerovox catalogue number for the correct replacement plate assembly.

RELAY CATALOGUE

45 American Relays has published a new catalogue covering an extensive line of relays and allied components. Included are time-delay relays, sensitive and plate relays, differentials, hermetically sealed types, keying and telephone relays, among others. The catalogue is completely illustrated with photographs and drawings.

INDUSTRIAL ELECTRONICS CATALOGUE

46 Newark Electronics Corporation has just issued an extensive 1962 industrial electronics catalogue listing many of the over 70,000 items the firm carries in stock from 500 top electronics manufacturers.

This 500-page catalogue is completely indexed by product and principal manufacturers to facilitate the prompt identification of components required by the service and industrial segments of the electronics industry.

TIMING MOTOR DATA

47 A. W. Haydon Company has available a data sheet describing in detail its 42100 Series of commercial-industrial a.c. timing motors. In addition to providing complete electrical and mechanical specifications, the data sheet includes outline and mounting dimension drawings and details on four types of output shafts.

These miniature motors are designed for applications ranging from clock drives to heavy-duty industrial control drives.

R.F. TEST EQUIPMENT

48 Jerrold Electronics Corporation is offering a short-form catalogue covering an extensive line of r.f. test equipment for quantitative measurements by comparison.

Included are sweep signal generators, crystal marker generators, spectrum generators, coaxial switches, voltage comparators, sweep-frequency filter test sets, coaxial cable test sets, precision attenuators, direct-reading tuned r.f. voltmeters, etc. Specifications and prices are included.

SOLID-STATE AMPLIFIER

49 Video Instruments Company, Inc. is now offering copies of its short-form catalogue of solid-state amplifiers for ground instrumentation, telemetry, and laboratory testing applications.

A variety of differential d.c. amplifiers is included in the brochure, such as chopper stabilized amplifiers, subminiature airborne amplifiers, galvanometer driver amplifiers, and "pure" direct-coupled amplifiers. The catalogue is designated "No. 4-1 DC Amplifiers."

TUNING-FORK OSCILLATOR

50 Fork Standards, Inc. has just published a colorful four-page brochure on tuning-fork oscillators featuring two series of transistorized models. Included are details on the Model C Custom series for exact high-precision requirements and the Model E Economy Series for less rigorous applications where low cost is important. Full details, including charts and drawings, are featured.

TRANSFORMER COLOR CODES

51 Stancor Electronics, Inc. is offering a handy wall chart which shows the EIA color codes for transformers. Included are color codes for power, audio, output, and i.f. transformers, as well as connection codings for loudspeaker leads and plugs. The chart measures 8½" x 11" and is printed on index paper stock.

MINIATURE CARBIDE TOOLS

52 The Atrax Company has available an 8-page brochure giving application information and prices on small, very small, and miniature precision ground solid carbide tools. This tool line is designed especially for electronics circuit board and instrumentation applications.

INSTRUMENT COUNTER DATA

53 Durant Manufacturing Company has announced the availability of its new Catalogue #400 which describes a complete line of mechanical and electrical instrument counters. The 16-page catalogue is designed as a ready reference for use by engineers in determining the counting instruments best suited to their particular applications.

MICROWAVE DIODE PRODUCTS

54 Sylvania Electric Products Inc. has issued a new microwave diode product guide which contains the electrical characteristics and performance ratings of a wide range of microwave mixer, detector, varactor, tunnel, and switching diodes. The publication also features a 4-page replacement guide insert, complete listing of mechanical and environmental test procedures, and more than six pages of microwave diode applications notes.

AUDIO-VISUAL SYSTEMS

55 Applied Communications Systems, a division of Litton Systems, Inc., has issued a four-page illustrated brochure which describes the applications of audio-visual systems and equipment in training and education.

SUBMINIATURE SWITCHES

56 U.S. Switch Corporation now has available a catalogue describing six subminiature switches which have been recently added to its line.

The types described in this new catalogue include standard, high-current, dry-circuit, long-life, high-temperature, and high-precision switches. Complete technical information and specifications are given. Also featured is a complete glossary of switch terminology.

METER-RELAYS APPLICATIONS

57 Assembly Products, Inc. has issued a 24-page bulletin which provides the complete story of locking contact meter-relays, including operating features and standard circuits for achieving the most popular types of control action.

Besides describing the new continuous reading meter-relay, which requires no reset, the bulletin covers isolated coils, double-locking coils, response time and damping, overload protection, and control components used with meter-relays. ▲

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___6AH6	.99	___6EM5*	.76	___12BL6	.56	___36AM3*	.36
___6AK5	.95	___6EM7	.82	___12BQ6	1.06	___50B5	.60
___6AL5	.47	___6EU8	.79	___12BR7	.74	___50C5	.53
___6AM8	.78	___6EW6	.57	___12BV7	.78	___50EH5	.55
___6AQ5	.53	___6EY6*	.75	___12BY7	.77	___50L6	.61
___6AR5	.55	___6F5GT	.39	___12BZ7	.75	___70L7	.97
___6AS5	.60	___6FE8	.75	___12C5	.56	___7025	.69
___6AS6	.80	___6GH8	.80	___12CN5	.56	___807	.70
___6AT6	.43	___6GK6*	.79	___12CR6	.54	___117Z3	.61

Popular New Tube Types Offered by Rad-Tel*

NOT AFFILIATED WITH ANY OTHER MAIL ORDER TUBE COMPANY

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Advertisers listed below with code numbers have additional information available on their products in the form of catalogues and bulletins. To obtain more detailed data, simply circle the proper code number in the coupon below and mail it to the address indicated. We will direct your inquiry to the manufacturer for processing.

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103	Audion	105
104	B & K Manufacturing Co	9
105	Blonder-Tongue	63
106	Bosco, Electronic Inc. Don	79
107	Browning Laboratories, Inc	78
108	Burstein-Applebee Co	105
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116	Columbia Stereo Tape Club	1
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	Conar Instruments	64
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128	G & G Radio Supply Co	118
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The coupon below can also be used to obtain additional information on the new product items shown on pages 106 through 111 as well as on the ads as listed above.

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NAME ____________________

STREET NO. ____________________

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MAIL TO **ELECTRONICS WORLD** P.O. BOX 212
VILLAGE STATION NEW YORK 14, N.Y.

INDICATE NUMBER OF ITEMS REQUESTED ☐

Make sure that your name and address are printed clearly.

ELECTRONICS WORLD READER SERVICE COUPON

Printed in U.S.A.

TRIPLETT

ACTUAL SIZE

USES UNLIMITED:

Field Engineers
Application Engineers
Electrical, Radio, TV, and Appliance Servicemen
Electrical Contractors
Factory Maintenance Men
Electronic Technicians
Home Owners, Hobbyists

MODEL 310

complete
VOLT-OHM-MILLIAMMETER

World's Largest Selling
POCKET SIZE V-O-M

FEATURES:

1 Hand size and lightweight, but with the features of a full-size V-O-M.

2 20,000 ohms per volt DC; 5,000 AC.

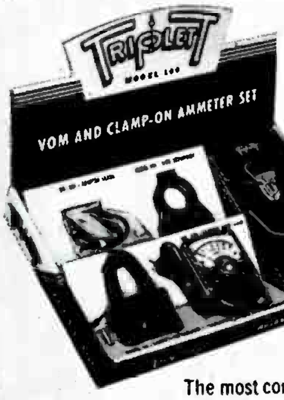
3 EXCLUSIVE SINGLE SELECTOR SWITCH speeds circuit and range settings. The first miniature V-O-M with this exclusive feature for quick, fool-proof selection of all ranges.

SELF-SHIELDED Bar-Ring instrument; permits checking in strong magnetic fields • Fitting interchangeable test prod tip into top of tester makes it the common probe, thereby freeing one hand • UNBREAKABLE plastic meter window • BANANA-TYPE JACKS—positive connection and long life.

■ Price—only $37.50; leather case **$3.20.**

Available For Immediate Delivery From Your Triplett Distributor's Stock

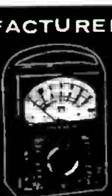
THE TRIPLETT ELECTRICAL INSTRUMENT COMPANY, BLUFFTON, OHIO



MODEL 100

The most comprehensive test set in the Triplett line is Model 100 V-O-M Clamp-On-Ammeter Kit, now available at distributors. The world's most versatile instrument—a complete accurate V-O-M plus a clamp-on-ammeter with which you can take measurements without stripping the wires. Handsome, triple-purpose carton holds and displays all the components: Model 310 miniaturized V-O-M, Model 10 Clamp-On-Ammeter, Model 101 Line Separator, No. 311 Extension leads, and a leather carrying case, which neatly accommodates all the components. Model 101 literally makes it possible to separate the two sides of the line when using Model 10. Extension leads permit use of Model 10 at a distance from the V-O-M. Complete Model 100 is only $64.50

MANUFACTURERS OF PANEL AND PORTABLE INSTRUMENTS; ELECTRICAL AND ELECTRONIC TEST EQUIPMENT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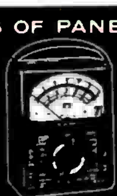
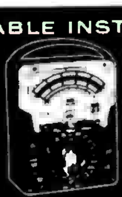

630-A


630-PL


630-APL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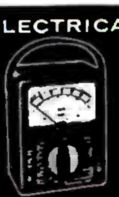
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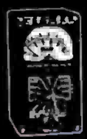
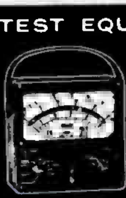

666-HH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666-R

FOR EVERY PURPOSE—THE WORLD'S MOST COMPLETE LINE OF V-O-M'S

"BUSINESS END" of a NOVAR tube

You're looking at the base of one of RCA's remarkable new novar tubes... the first in a new family of tubes that will mean better business for you through reduced call backs.

This new base—with 9 widely-spaced, heavy-gauge pins—characterizes novar, RCA's line of large all-glass integral base tubes designed to do the work of conventional tubes with molded bases. Because novars *outperform* these conventional types, they are being selected for use in more and more radio and TV receivers as well as hi-fi equipment. From present indications, novar should become the standard of the industry.

Look for novar, RCA's latest contribution to electron tube design. Your Authorized RCA Electron Tube Distributor now has RCA-7868 novar and will soon have many other types to support your servicing business.

RCA ELECTRON TUBE DIVISION, HARRISON, N.J.

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