Electronics World

MAY, 1966
60 CENTS

WILL SATELLITES BE USED FOR HOME TV?

HOW TO SELECT ATTENUATORS AND PADS

CHOOSING THE RIGHT R.F. CHOKE

ULTRASONICS IN MEDICINE

TV TAPE RECORDERS
—for Home and Industry

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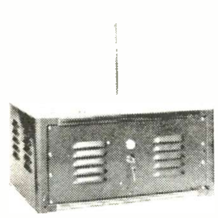

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THIS MONTH'S COVER shows two home video tape recorders along with a camera designed for home use. The unit at the top is the tape-deck portion of the Ampex recorder while the unit shown in the inset below is the Sony home video machine. We have removed the tape-head covers along with the front covers and shields in order to show some of the internal components. The Ampex camera at the lower left is for use with the manufacturer's home video machine. Technical articles in this issue cover both recorders and compare the various techniques employed for video tape recording. . . . .
Color photo by J. R. McKenney; inset photo by Bakalar-Cosmo Photographers.

Electronics World

MAY 1966 **VOL. 75, No. 5**

CONTENTS

MONTHLY FEATURES

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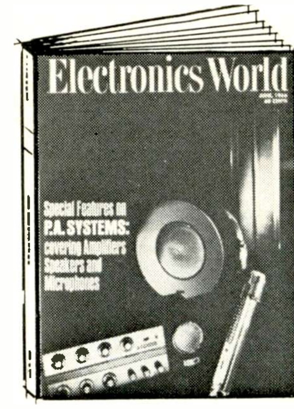
COMING NEXT MONTH



Special Feature Articles on: PUBLIC-ADDRESS SYSTEMS

Our June issue will carry three important features of special interest to all those involved in planning, installing, and maintaining public-address systems.

Abraham B. Cohen, manager of engineering of University, tells how to select the proper speaker, how to obtain correct sound coverage, and how to connect such transducers.

M. S. Sumberg of Bogen's Sound Products Division explains how to pick the right p.a. amplifier. He covers various types of p.a. installations and makes recommendations about equipment to handle each particular type of job.

Paul K. Franklin of Electro-Voice emphasizes how important the proper selection of a p.a. microphone and its correct placement are in obtaining the required frequency response, directivity, and output level in the system.

SEALED LEAD-ACID BATTERIES
This newest advance in sealed, compact power sources which offers the highest cell voltage, heavy drain capability, and maximum watt-hour capacity at extreme temperatures is discussed in depth by E. T. DeBlock and John R. Thomas of Globe-Union's Battery Division.

VARACTOR DIODE APPLICATIONS
These special semiconductor diodes which operate as "high-Q" electronically variable capacitors are finding increasing use in a.f.c. circuits, FM modulators, harmonic generators, and parametric amplifiers. Includes a list of firms that make such units and the types they sell.

CHROMA SYNC IN COLOR SETS: RCA
This second article in the current series on the specialized circuitry to be found in color television receivers, covers the sync circuits of RCA's sets.

SAMPLING OSCILLOSCOPES
Signal sampling techniques permit laboratory-type scopes to extend their vertical-bandpass capability up to the equivalent of 1000 MHz—allowing the measurement of very rapid waveforms.

*All these and many more interesting and informative articles will be yours in the June issue of ELECTRONICS WORLD . . . **on sale May 19th.***

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For the record

WM. A. STOCKLIN, EDITOR

CATV—A BOOMING NEW INDUSTRY

THE birth of community antenna television systems occurred over 15 years ago, in 1950, when the first commercial installation was made in Lansford, Pa. It was an insignificant beginning and few people at that time could have anticipated its potential growth.

In just over 15 years CATV systems have been connected to 2 million homes. Today some 1600 systems are in operation, covering all 50 states and the Virgin Islands. As of January 1st, there were approximately 250 systems in various stages of installation, about 600 additional communities had issued permits but construction had not yet started, and approximately 1200 applications were pending before local governing bodies. Each month there are some 90 applications for new CATV installations.

While these facts are impressive, the future holds an even greater potential. It is predicted that this year some 1 million additional homes will have a CATV connection. The ultimate potential is some 52 million homes. Some day every hamlet, town, and city will be interconnected like a massive spider web.

CATV will become as common as the telephone connection and each home will receive, on one or more sets, dozens of channels providing education, cultural material, and entertainment.

For those who have not been convinced as to the need for cable systems, let us refer to the often-quoted Seiden Report. According to this report, there are nine states that do not have a single 3-station market, and in 14 other states there is only one 3-station market each.

For those who believe that cable systems are confined to rural areas, let us note that New York City has issued franchises for several companies to do CATV installations. Construction has started and it is hoped that it will be completed by the end of the year.

The successes of CATV to date have not been achieved without problems. There were roadblocks no matter which way the CATV operators turned, but they met each challenge successfully and today they are operating without control by any state or federal agency. This certainly is not objectionable since it has encouraged a new and budding industry to bloom, and we are firm believers in the free-enterprise system. For many manufacturers in the electronics industry, this has meant new customers. Thousands of dollars are spent daily for cable and electronic equipment, not to mention all the miscellaneous items required for such a system.

But, a day of reckoning must come, certainly not to curtail CATV, but to set operating ground rules for free television and CATV. Up to several weeks ago, both Congress and the FCC had turned their attention elsewhere. Even the Public Utility Commissions have declared that CATV does not come under their jurisdiction. There have been many court encounters but only one state—Connecticut—has indicated that such service comes under the jurisdiction of its PUC.

Not too long ago, FCC Chairman E. William Henry announced that the FCC would study all of the problems and shortly thereafter, on Feb. 15, he announced that CATV does come under FCC jurisdiction, and immediately proceeded to set regulations. In addition, he made major requests to Congress.

1. That CATV systems be required to get the consent of originating stations for re-transmitting their signals over CATV. This implies that a copyright fee might be imposed on CATV operators.

2. That CATV systems should be classified as public utilities.

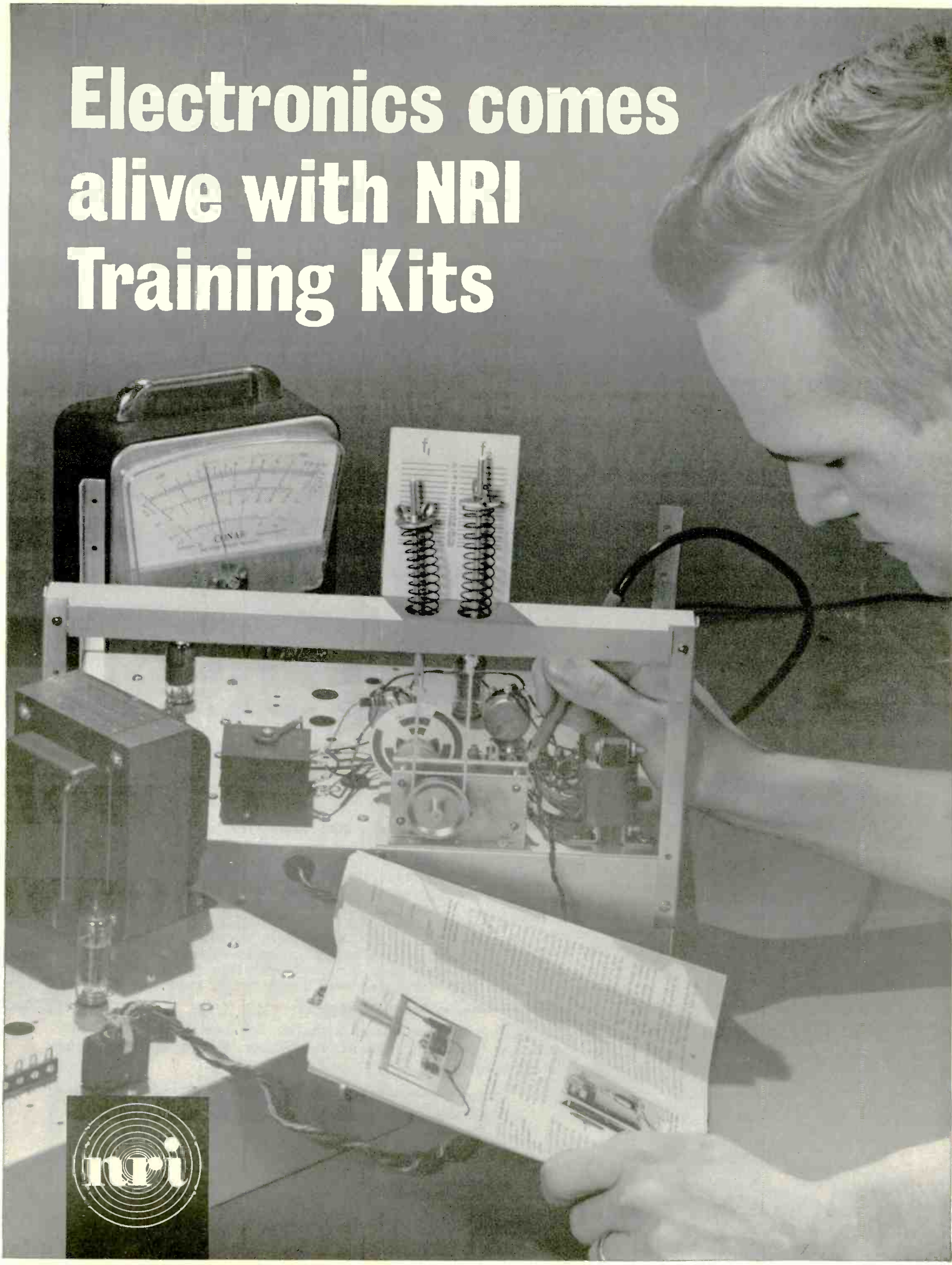
3. That CATV operators be prohibited from originating programs of their own, thereby automatically blocking the development of CATV into a form of pay-TV.

This is the start of another series of court battles. FCC member Robert B. Bartley said that he did not agree that the Communications Act confers jurisdiction over CATV to the FCC. Even Chairman Henry said the question of jurisdiction probably will be decided by the Supreme Court.

If past performance of Congressional and Supreme Court actions is any criterion, it will be a long time before any regulations will be enforced.

Getting back to the items listed above, we believe the first should be enacted only to conform to present copyright laws. We believe item 2 will become a reality, but that item 3 is unrealistic in the broad sense. We do not believe there is any organization, including the FCC, that really wants to stifle CATV progress. There is a definite need for cable systems and eventually CATV will provide additional services now unknown to us and in a way free TV cannot.

We feel sure that a set of rules and regulations will emerge that will neither hinder the continued growth of cable systems nor permit the demise of free TV broadcasting. The decisions will set ground rules so that both can operate free of legal problems and prosper side by side. Harmonious cooperation between the two must be the eventual goal. ▲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HI-FI PRODUCT REPORT

TESTED BY HIRSCH-HOUCK LABS

Harman-Kardon SC-440 "Stratophonic" System

Harman-Kardon SC-440 "Stratophonic" System

For copy of manufacturer's brochure, circle No. 27 on Reader Service Card.

DESPITE the numerous advantages of component high-fidelity systems over ordinary packaged radio/phonographs, the complexity (real or imagined) of assembling one's own system has kept many from enjoying the benefits of high fidelity. The integrated stereo receiver represented a giant step toward simplifying system planning and, understandably, has captured a large share of the component market.

Nevertheless, for many people, the selection of a record player, cartridge, and speaker system is so confusing that they are not tempted by the availability of integrated receivers. For them, the compact, integrated system may well be the ideal solution. This offers, under the control and warranty of one manufacturer, a record changer, cartridge, amplifier, and speakers, attractively packaged for installation without additional cabinetry. Some models are also available with built-in tuners, forming a complete high-fidelity system.

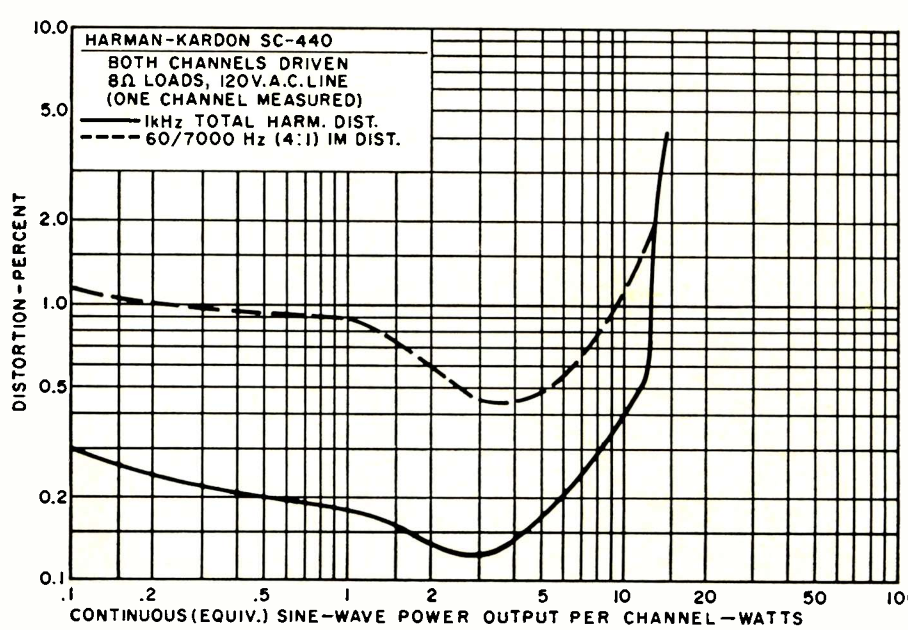
The new *Harman-Kardon* SC-440 "Stratophonic" system is perhaps the most complete integral system we have seen, for it includes an AM tuner and FM-stereo tuner in addition to the other essential components. The walnut cabinet base houses a solid-state receiver similar to the firm's SR-400 "Stratophonic" receiver. On top of the base is a *Garrard* AT-60 automatic turntable fitted with an *ADC* 770 cartridge.

On the sloping front panel of the receiver are the input switch (which also serves as a stereo/mono mode selector), the volume control and "on-off" switch, bass and treble tone controls, balance control, and tuning knob. The edge-lighted slide-rule dial has AM, FM, and logging scales. An automatic stereo indicator light and tuning meter are located on the dial scale. Switching between mono and stereo FM reception is automatic. Two slide switches control the loudness contour and cut off the speakers for headphone listening *via* the front-panel phone jack.

In the rear of the control unit are inputs for a high-level auxiliary source or tape recorder, and tape recording outputs which are unaffected by the tone and volume-control settings. The unit has a built-in AM antenna, although a longer wire can be connected where needed. A 48-inch wire is supplied for an FM antenna and conventional FM antennas may be used in weaker signal areas.

The system is supplied with its own speakers and the usual screw terminals at the amplifier and speakers have been replaced by ordinary phono jacks. A pair of 24-foot cords is supplied, giving the user a wide choice of speaker locations.

The speakers of the SC-440, more than anything else, distinguish it from other compact music systems. They are not in any sense miniature, but rather are full-sized, heavy "bookshelf" (23" x 13½" x 10") units weighing about 30 pounds each. Low frequencies are han-



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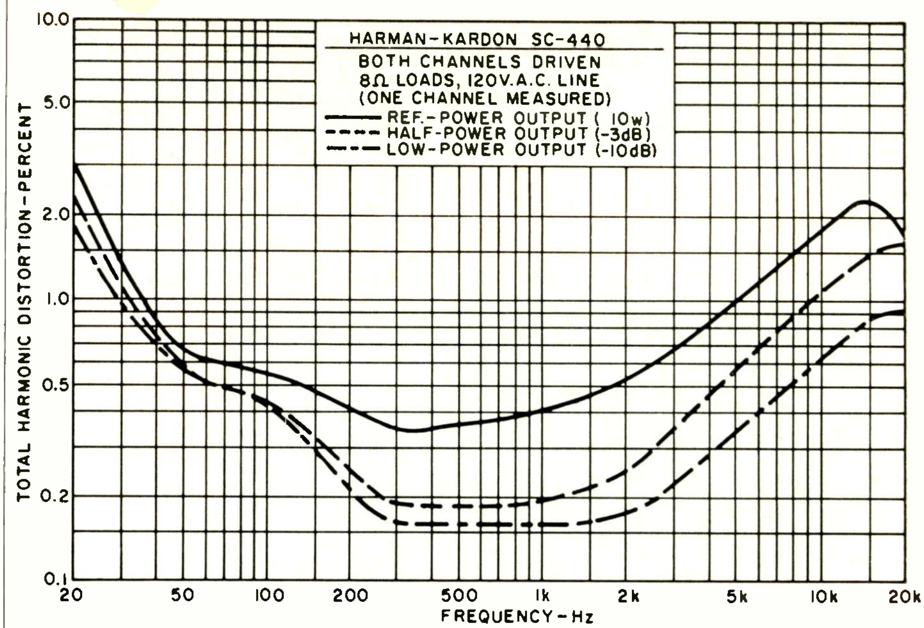
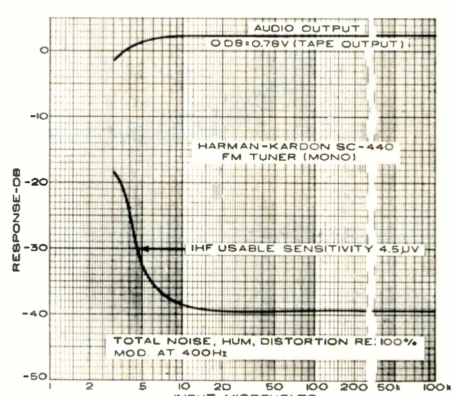


dled by a 10″ acoustic-suspension woofer, with a highly compliant cone surround. High frequencies are radiated by a 3½″ cone tweeter, with a level control for the tweeter on the back of the speaker cabinet.

In testing the unit we measured the receiver performance as though it were a separate unit, driving 8-ohm resistive loads. Since the frequency response is not shaped in any way to compensate for speaker response, we felt justified in testing the speakers independently. The record player and cartridge were not tested, other than by normal use and listening since they are standard commercial units and are not peculiar to

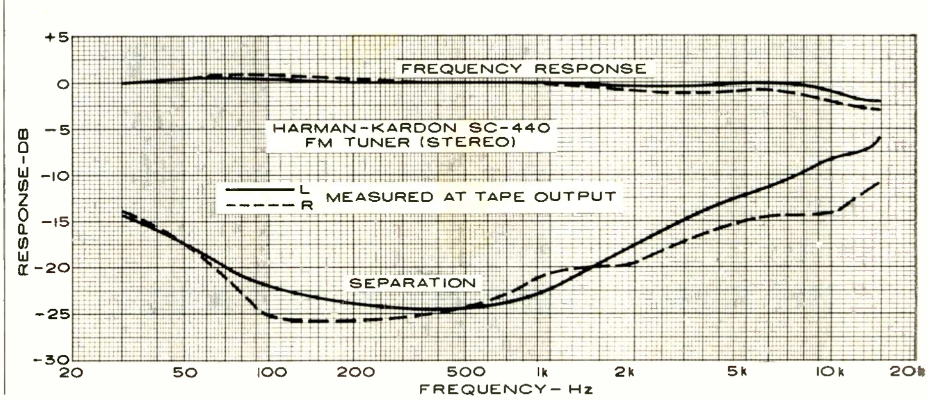


this particular integrated stereo system.

The receiver is a simple, yet effective design. The FM front-end has a tuned r.f. stage, mixer, and separate oscillator. The AM tuner has no r.f. stage. Four i.f. stages are used for FM followed by a ratio detector. In AM reception, three of them are used, with a separate diode detector. The multiplex circuit is unusually simple, with only two transistors (plus another to operate the stereo indicator lamp) and a four-diode balanced modulator.

The audio section has feedback-equalized phono preamplifiers. The driver transistors are transformer-coupled to the output stages, which are directly coupled to the speakers. The power supply provides five positive voltages and four negative voltages, individually filtered for maximum decoupling.

The manufacturer does not supply any performance specifications with the SC-440. We measured a continuous power output of about 13 watts per channel (by the new IHF measurement standard) at 2% distortion (either harmonic or IM). The 1-kHz harmonic distortion was very low, under 0.3% up to 8 watts output. The IM was in the vicinity of 1% below 1 watt, falling to less than 0.5% and reaching 1% again



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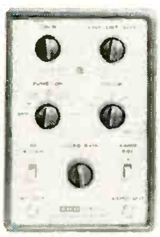

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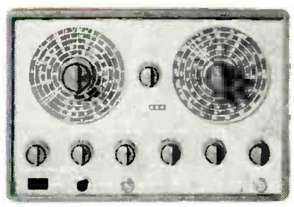

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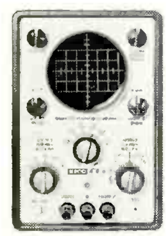

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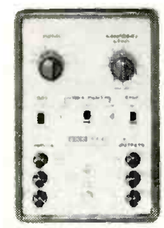

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at 9 watts output. Referred to 10 watts and 2% distortion, the power bandwidth (at −3 dB) was 22 to over 20,000 Hz. *(We subsequently learned that the loudspeakers employed are 4-ohm units. If we had used 4-ohm rather than 8-ohm loads, power output would be greater than the figures given above.—Editor)*

With the tone controls centered, the over-all frequency response was within ±1 dB from 20 to 20,000 Hz. The tone controls cover a range of +8.5, −6.9 dB at 50 Hz and +17.7, −8.0 dB at 10,000 Hz. The loudness compensation boosts only the low frequencies at reduced volume control settings.

The FM tuner had an IHF usable sensitivity of 4.5 microvolts with limiting essentially complete at 10 microvolts. Its frequency response was ±1 dB from 30 to 15,000 Hz. Stereo separation was 25 dB at middle frequencies, reducing to 14 dB at 30 Hz and 6 to 11 dB at 15,000 Hz. *(The model tested was an early unit that had a low-"Q" multiplex coil. According to the manufacturer, later versions have better stereo separation, especially at the higher frequencies.—Editor)*

The speaker system (designated Model HK-40) had an exceptionally smooth over-all frequency response, with a middle and high range as smooth as we have ever measured on a dynamic speaker. From 1000 to 15,000 Hz the response followed our microphone calibration curve within about 1 dB. The smoothness we measured, averaging nine sets of data made with different microphone positions in a "live" room, was further confirmed by the excellent tone-burst response. The tone burst taken at 1.6 kHz is typical of the speaker's performance over most of its range. The only point of significant ringing was at about 800 Hz.

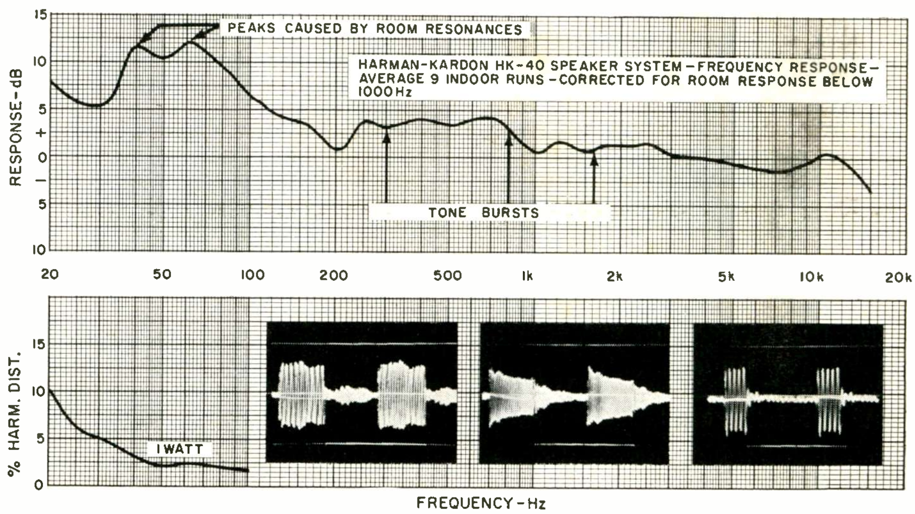
Below 1000 Hz, we usually apply a corrective curve, based on many speaker tests in the same environment, which corrects for much of the effect of the room on the speaker's low-end response. The resulting response curve shows a rise below 200 Hz, amounting to about 10 dB between 40 and 60 Hz. Some of this undoubtedly was the result of low-frequency room resonances as indicated on the curve. However, the very low bass distortion (only 5% at 30 Hz with 1-watt input) makes the low-frequency output of the HK-40 true and usable over its entire range.

From the moment we turned on the SC-440 system, it was apparent that this was no ordinary "compact" music system. The over-all sonic balance was extremely pleasing. In particular, the bass performance was far beyond what we would have expected from a system of such a moderate price. The low bass can actually be felt rather than heard—and the clarity and smoothness of the speakers' response makes them the equal of almost any speaker we know of in the $100 to $150 bracket.

The FM receiver delivered excellent performance using only the 48-inch wire supplied as an antenna. In fact, we never felt the need for a better antenna in our suburban New York location. The tuner was drift-free, tuned easily, and sounded fine. The audio power was more than sufficient for the speakers, which evidently are relatively efficient. The AM tuner, which we did not measure, sounded as good as we would expect of any AM receiver, and is adequate for its intended purpose.

The record player and cartridge sounded fine on stereo records, tracking at 3 grams. On some older mono LP's, we observed some distortion, which may have been due to the stylus radius being too small for their grooves.

The components of the SC-440, if purchased separately, would cost about $525, assuming a price of $100 each for the speakers (and they would be a good value at that price). Obviously, the complete price of $429.00 for the system makes it an outstanding value. We have no hesitation in recommending it to anyone who wants true high-fidelity performance in a moderate-priced integrated system. ▲



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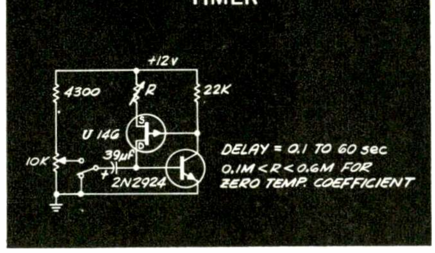
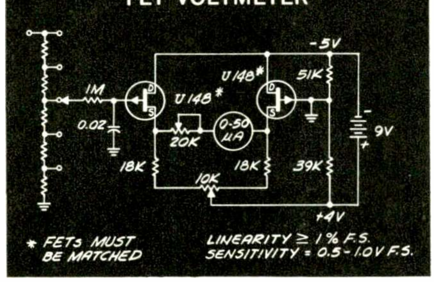


This basic circuit can be used for an enlarger timer, metronome, or other timing device.

FET VOLTMETER



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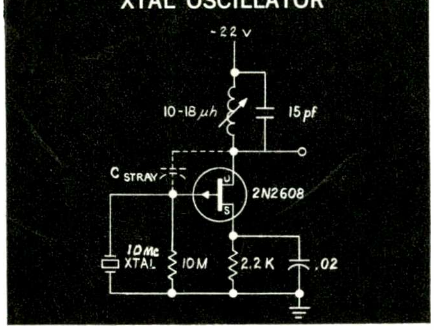

The high impedance of a crystal works hand-in-hand with the high-Z FET.

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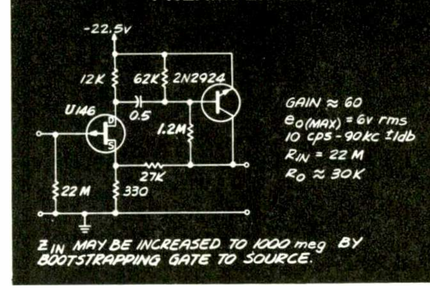

This mike preamp could be built into the mike's case, complete with battery operated by the PTT switch. A FET source-follower stage would provide a low-Z output to long mike lines.

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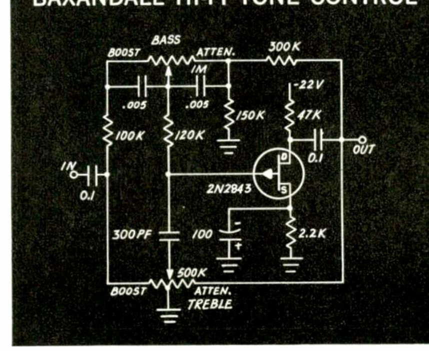
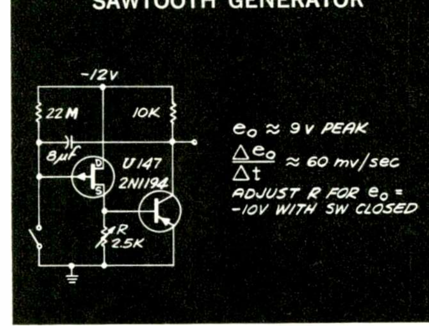


SAWTOOTH GENERATOR



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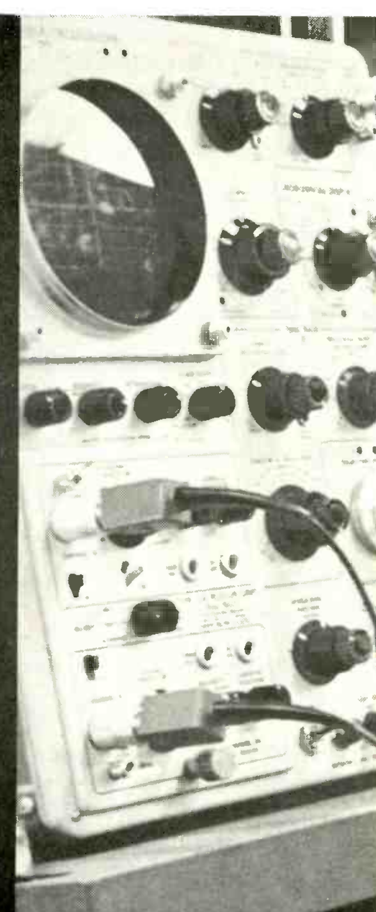

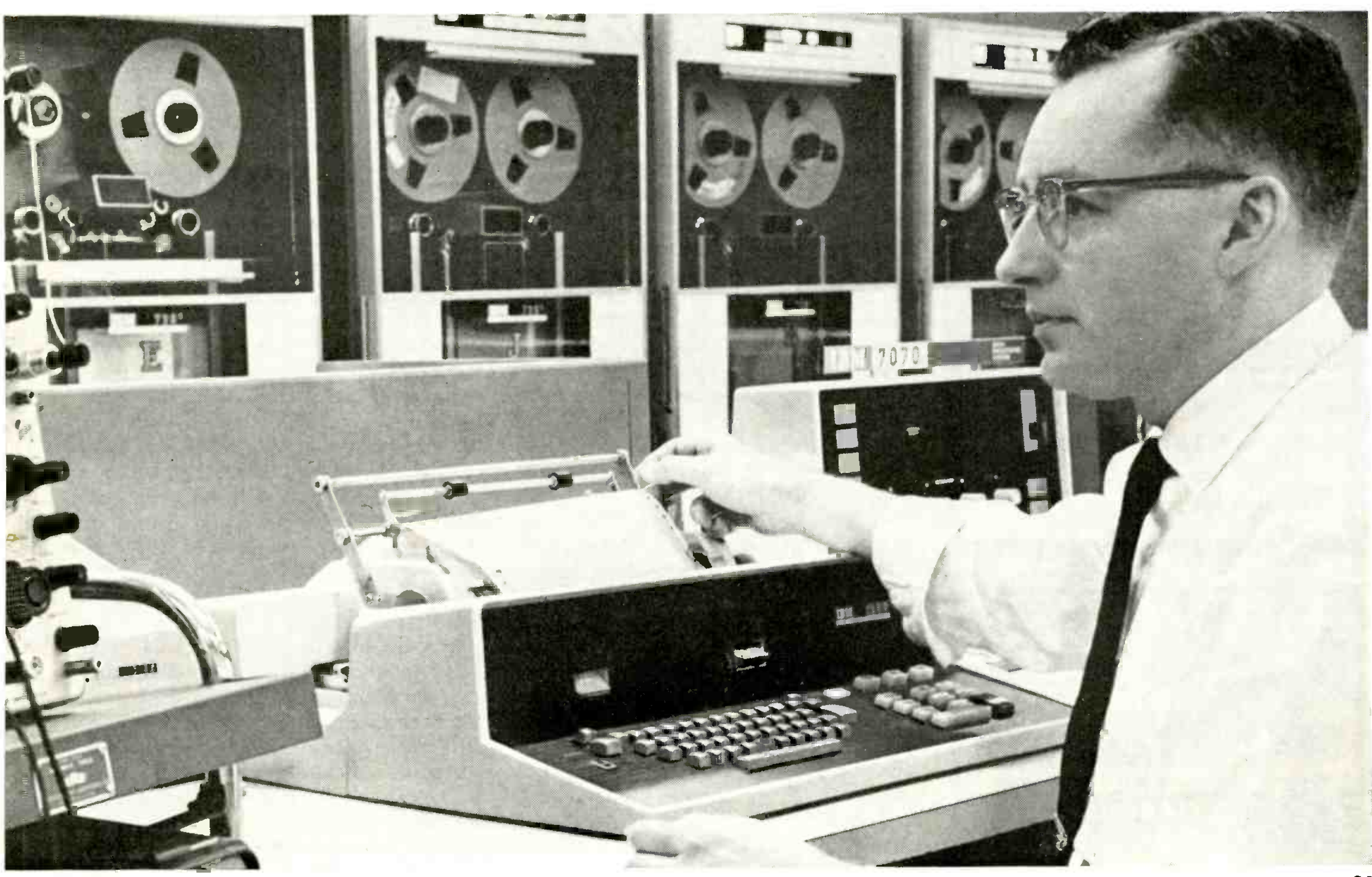
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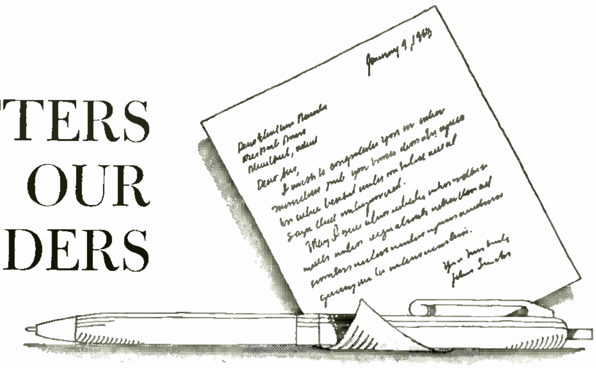
LETTERS FROM OUR READERS



TIME MEASUREMENTS

To the Editors:

I am giving a series of noontime lectures in astronomy for our astronomy club at the office *(Bell Telephone Labs.)*. We recently covered astronomical time measurements. Consequently, my attention was attracted by your "Time Scales & Time Measurements" article in ELECTRONICS WORLD for January, 1966. Before I condemn the article, I want to say that I actually did learn something from it. And now for the points of criticism.

Regarding the variations between lengths of apparent solar days, even if the earth's orbit were perfectly circular and there were no eccentricities in the axis, the apparent solar days would *not* be of uniform length. Variations would exist because of the inclination between the orbital plane and the equatorial plane. However, a solar day in November is never more than seconds different in length from a day in June, and certainly nothing like the 16 minutes stated by the author.

Consider the following statement in the "Ephemeris Time" section. "Due to the tremendous distances, these celestial bodies, except for the nearer planets, appear to be motionless in space." Truth of the matter is that all celestial bodies appear to be moving in space and this is regardless of distance. Stars exhibit motions such as proper motion, aberration, and parallax. These motions must be accounted for in coordinate measurements. There is apparently nothing fixed in the heavens.

Under the heading "Sidereal Time," the author states ". . . . if the earth is going away from the sun, it must rotate more than 360 degrees to present the same point to the sun as shown in Fig. 1. The opposite is true when the motion of the earth is toward the sun." That is patently untrue. The excess rotation beyond 360 degrees is required because the earth is revolving about the sun, and this excess rotation is required whether the earth is going toward or away from the sun. The picking of a reference point farther from the sun does not lessen the effect, as the author stated. It eliminates the effect, as such. Of course, the orbital motion still causes problems, but not that one. The author now gets involved with the subject of sidereal time.

Sidereal time is more important than one is led to believe. It is really one of the most basic times measured. Most other times are derived from it or corrected by measurement of it. Sidereal time is defined in terms of the interval between transits of the vernal equinox —a point, not a body. And there are two sidereal times, apparent and mean, just as there are apparent solar time and mean solar time. The difference between them is not caused by the same thing, however. Sidereal time is actually measured by observing the transits of various stars whose positions relative to the vernal equinox are accurately known.

As for the eastward motion of the sun in the sky, I, in contrast to the author, have no doubt that most people have *never* noticed such an eastward motion. Most probably have never even heard of it. After all, when you are looking at the sun in the sky, there is nothing else there to relate its position to. How can you see any eastward motion by looking at it at the same time each day? When you compare its position with terrestrial objects there is certainly no progressive eastward motion. I don't say such a motion does not exist; it does. It is just not that apparent, and is in fact most easily discovered by noting that it is the stars that are in a different position at the same time on successive nightly observations. Then, by inference, one decides the sun must have moved eastward. I can only guess at what the author meant by the statement, "At the end of a year's time the sun, in its apparent orbit around the earth, will have then added one extra day."

There is nothing curious about there being one more sidereal day in a sidereal year than solar days in the solar year. That statement includes four time units, and the relationships among them have not been given. The reader is thus in no position to come to such a conclusion. I assume the author meant the term solar year to be a tropical year, the one we use for our calendars. Maybe another reason for the statement not being curious is that it just is not really true in the first place.

KENNETH E. STONE
Marlboro, N.J.

Following is a portion of Author Wilson's reply to Reader Stone's letter.—Editors

To the Editors:

My thanks to Reader Stone for pointing out the mistake in the second paragraph under "Sidereal Time." It should be noted that there is always some additional amount of rotation because of the orbital motion. The amount of additional rotation increases or decreases as the earth moves away from or toward the sun, respectively. This is why the apparent solar days are of unequal duration when compared to a more accurate reference.

Let me repeat and emphasize the difference between an apparent solar day and a mean solar day. An apparent solar day is the duration of time required for one rotation of the earth placing the sun back in its apparent position in the sky. A mean solar day is the average of all the apparent solar days in one solar year. Because of this, an apparent solar day is different at different times of the year. In November, this difference is at its greatest due to the earth's being near its aphelion of orbit (most distant point from the sun).

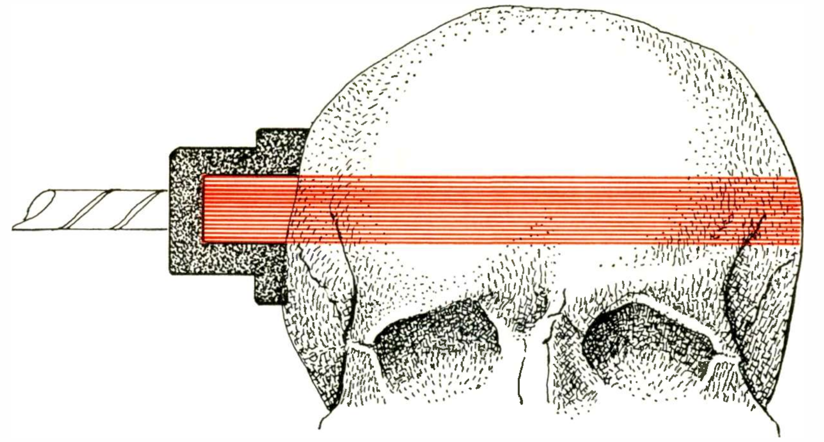
With regard to the section on ephemeris time, an extension of the context would include the next sentence, "Therefore, at regular intervals of ephemeris years, these celestial bodies appear to return to the same relative positions in the heavens." This regular interval is the ephemeris year and is, as stated, constant enough to be a reference.

I have only suggested that the distant stars appear motionless. I didn't say they did not move. The important point is that they regularly return to the same relative positions, thus offering an accurate reference.

My mention of sidereal time was not intended to belittle it. I repeat that sidereal time is of little use in the majority of measurements in electronics, just the same as solar time and in contrast to the UT-2 scale. As to how to reference sidereal time, although I did not use the imaginary point that Reader Stone knows as the vernal equinox, common sense requires that there be some point of reference.

As to the remainder of the disagreements, Reader Stone has pointed out only one possible misstatement in the article and is, instead, taking issue with the conciseness with which the story was written.

EDWARD C. WILSON III
Rialto, Calif. ▲



ULTRASONICS in Medicine

By ABRAHAM KAGAN

Survey of increasing use of "silent-sound" waves for physiotherapy, as a diagnostic tool, and to destroy malignant or unwanted tissues.

THE application of ultrasonics to medicine is over twenty years old, but recent years have seen a remarkable quickening of both the scope and the pace of the development of this medical tool. Today there are significant advances that may revolutionize medical diagnostic procedures. As Dr. Joseph H. Holmes of the University of Colorado Medical Center and one of the leading researchers in this field puts it: "We may well visualize the patient of the future systematically scanned by ultrasound while electronic recorders feed the information into computers which process the data and arrive at a diagnosis."

While such computerized patient management is still admittedly in the realm of scientific imagination, sufficient real progress in research, instrumentation, and interpretation has taken place to move the concept out of the area of science-fiction and into the realm of science-fact.

Ultrasonics has been used in three well-defined medical areas: for physiotherapy of numerous skeletomuscular and neuro-muscular disorders; for diagnostic purposes to depict anatomical structures and pathological processes; and surgically, for destruction of malignant or unwanted tissues. In this article we will not be concerned with the common uses of ultrasonics for dental drilling and cleaning surgical tools.

Frequencies, Power Loads, Transducers

Any sound wave, whether sonic or ultrasonic, is produced by actual mechanical motion of the particles of the material through which it passes. The energy of the wave is propagated longitudinally—in the direction of the wave motion—resulting in a series of alternate compressions and rarefactions in the propagating medium. The two principal characteristics of such a wave are frequency and intensity.

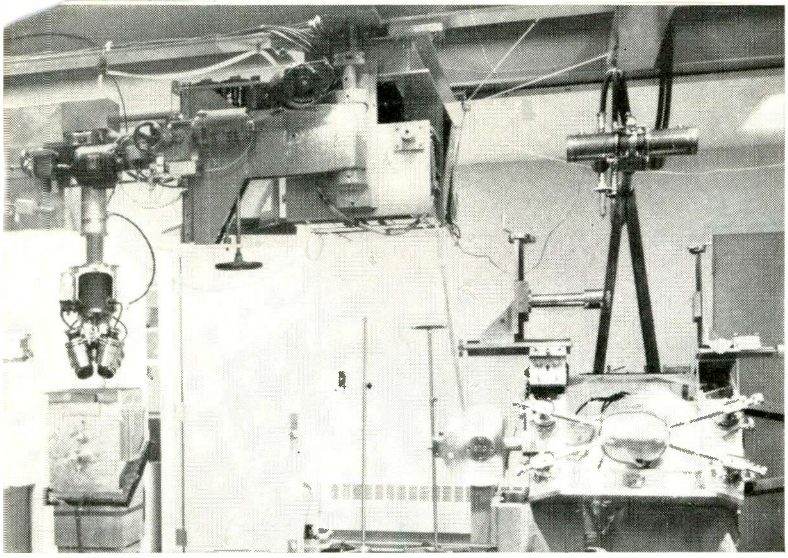
The ultrasonic range includes sound waves with a frequency greater than the normally audible limit of 20,000 Hz, but the frequencies used for most medical applications are much higher—from just below 1 MHz for physiotherapy to as high as 15 MHz for diagnostic applications. The reason for this is that the best resolution is provided by the shortest wavelengths (from about 1.5 mm to about 0.10 mm in fluids and soft tissues, corresponding to 1 to 15 MHz). The upper limit of the usable frequencies, however, is determined by the absorption of ultrasound by the tissues. Soft tissues attenuate the sound-wave power or intensity by about 1 dB (or 25%) per cm per MHz. Thus, the most useful diagnostic frequencies range from approximately 2 MHz for applications where bone penetration is involved to 10-15 MHz for applications involving soft external organs such as the eye or the breast.

While the *frequency* of medical ultrasound varies only by a factor of 10, the *intensity* of the applied waves may vary by a factor of 10^5 or more, depending on their medical application. The power levels used for diagnostic studies are the lowest, ranging from 0.001 to 0.04 watt per cm^2. Recent improvements in ability to measure intensity of sound actually entering tissue show that most routinely performed diagnostic procedures expose tissue to no more than 0.01 watt/cm^2. Intensities from 0.1 watt to 1.5 watts per cm^2 are used for physiotherapy. Surgical applications entailing destruction of tissues require intensities ranging from 4 watts to as high as 1500 watts per cm^2.

The transducers which convert electrical to sound energy and *vice versa* are usually piezoelectric crystals or ceramics of barium titanate, lithium sulphate, or lead zirconate-titanate. Crystal size varies because there is a predictable relationship between the dispersion of the sound beam and the number of wavelengths across the crystal face. Crystals from about ⅙ in to 1 in in diameter have been used with the most common diameter of commercial diagnostic crystals being about ¾ in. The problem of improving lateral discrimination for diagnostic and surgical application has also been approached by acoustic converging lens directly in front of the crystal or by bowl-shaped focusing transducers. Ceramic transducers have also employed small liquid-filled coupling chambers in order to obtain improved efficiency.

Physical Therapy

Of the three broad areas of application mentioned, probably the most widely practiced is that of physical therapy. According to Dr. John H. Aldes, executive director of the American Institute of Ultrasonics in Medicine, some 50,000 doctors and therapists in the United States are now employing ultrasonic



Equipment for ultrasonic surgery at Biophysical Research Lab at Univ. of Illinois. At left are four focused transducers suspended from massive overhead track. To right is operating platform with four steel pins holding skull model. Equipment is rigid enough to assure repeatability of location of focused ultrasonic beams in tissue to within a thousandth of an inch.

energy for the treatment of a wide variety of conditions ranging from athletic injuries such as the familiar "charley horse" to bursitis, various types of arthritic, rheumatoid, and gouty conditions and joint pathologies and a variety of neuromuscular and vasomotor disturbances. Clinical usage of ultrasonic energy is already taught in every school of physical medicine approved by the American Medical Association.

For therapy, a continuous ultrasonic beam is used. The tranducer can be held in direct contact with the patient's skin which is coated with mineral oil or a similar acoustic coupling material. When more convenient, the part to be treated is immersed in water and the transducer held about an inch away from the area to be treated. The dosage is a product of the intensity of the sound beam and the length of time it is applied to a particular area. The equipment manufactured for ultrasonic therapy is generally calibrated and may be preset in terms of these two parameters. The duration of a single treatment generally does not exceed several minutes with a series of treatments usually being required. According to Dr. Edwin Matlin, secretary of the AIUM, ultrasonic physical treatment is self-protecting since any excessive dosage makes itself self-evident, before any damage can be caused, through a characteristic cramping sensation experienced by the patient.

Although the exact physiological mechanism of the effects of ultrasound upon living tissues is not yet thoroughly understood, it has been determined that in addition to generating deep-seated heat similar to that produced by conventional diathermy, ultrasound produces certain mechanical and chemical effects on cell molecules. The results include a decomposition of some macromolecules, increased vascular and fluid circulation, and an increase in membrane permeability. The effects of this ultrasonic "micromassage" add up to frequent relief from soreness and pain, improvement in joint motion, healing of skin ulcers, elimination of phantom limb pain, and stretching and softening of scar tissue.

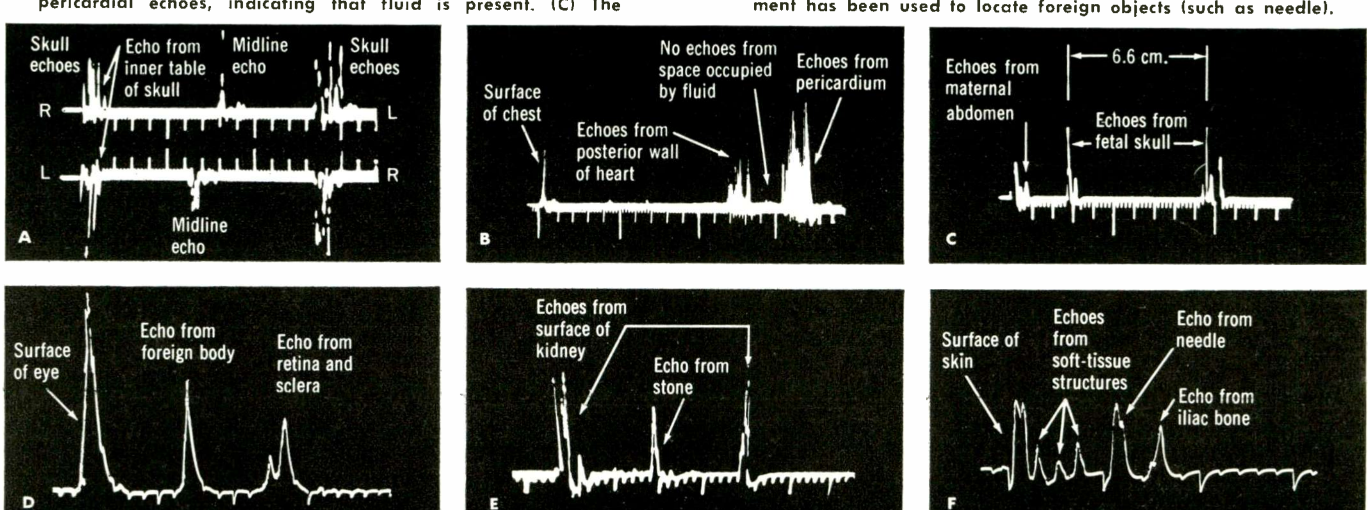
A recently developed adaptation of ultrasonic physiotherapy technique takes advantage of the ability of ultrasound to force certain steroids through the intact skin. In this technique, hydrocortisone, which is conventionally injected into the joint area by means of a hypodermic needle, is simply applied to the affected areas in the form of an ointment. The ointment serves as an acoustical coupling agent and at the same time is ultrasonically "pumped" through the skin into the underlying tissues. In another variation, the hydrocortisone is injected just under the skin surface and is then diffused deeper into the tissues ultrasonically.

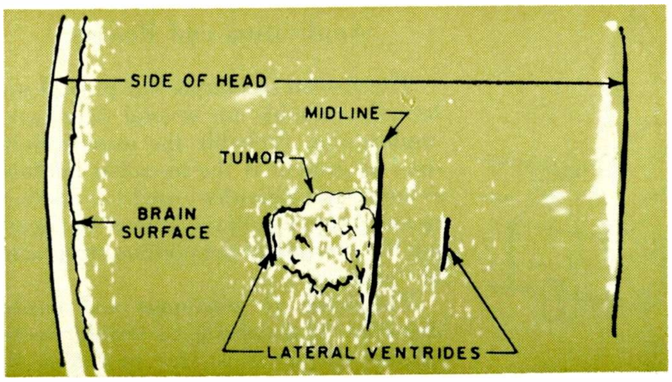
Diagnostic Ultrasound

The history of ultrasonics for medical diagnosis bears an interesting contrast to the use of x-rays for the same purpose. While x-ray photography was used to diagnose bone fractures within a year of Roentgen's discovery in 1895, Galton's invention of the ultrasonic dog whistle remained merely a scientific curiosity for almost 60 years. It was only with World War II developments in radar and sonar that the basic tools for the application of ultrasound for medical diagnosis became available.

Analysis is made possible by the following facts. Various tissues have specific acoustic impedances which depend on their density and elasticity. Whenever the ultrasonic wave encounters an interface between two media differing in either of these two characteristics, part of the wave is reflected. The greater the mismatch, the larger the reflection. A wave in a homogeneous medium may be attenuated by absorption which depends on the molecular constitution of the material and, in case of liquids, on their viscosity. In relatively nonhomogeneous media another phenomenon encountered by the ultrasonic wave is scattering. This is due to multiple reflections from many small random interfaces. To sum up, an ultrasonic wave is modulated by, and thus can be used to depict, several mechanical properties of biological tissues such as their density, elasticity, viscosity, molecular structure, and in-

A number of A-scan displays from Smith Kline diagnostic ultrasonic equipment. (A) Brain midline displacement of 8 mm to left indicating presence of space-occupying lesions. (B) Echoes from posterior wall of the heart's left ventricle are separated from pericardial echoes, indicating that fluid is present. (C) The width of a fetal head within the uterus can be measured. (D) A brass fragment in the eye is located with great accuracy. (E) A stone, located 20 mm from the probe being held against the surface of kidney, is indicated. (F) In various soft-tissue sites, equipment has been used to locate foreign objects (such as needle).





B-scan display showing a 2-cm brain tumor. Notice the midline displacement toward the right in this photograph.

terfaces. Identifying anatomical structures in terms of these properties and relating them to the presence or absence of pathology are the fundamental problems of medical diagnostic ultrasonography.

In the earliest ultrasonic diagnostic experiments, performed in 1942, visualization of the head was attempted with a continuous acoustic wave. By using a transmitting transducer on one side of the head and a receiving transducer on the other side, it was hoped to plot the regions with different sound transmission characteristics and thus to localize the position of liquid-filled brain ventricles. The ventricles can be visualized with x-rays only if they are drained through a spinal tap and injected with air to provide sufficient x-ray contrast—a procedure which entails some pain and risk to the patient. However, variation in the strength of the received signal due to absorption and refraction of the sound energy from the bones of the skull was so large as to mask the variation due to the ventricles.

Much greater success was achieved by the adaptation of the pulse-echo technique developed at that time for the detection of flaws in metal. In this system a pulsed beam of ultrasound is directed into the structure to be examined and the echoes, reflected from discontinuities or interfaces between media of varying acoustic impedances, are detected and displayed on the screen of a cathode-ray tube.

In the human body strongest echoes are reflected from relatively hard structures such as bone, stone-like deposits or formations, or foreign bodies. However, the ultrasonic pulse apparatus has been refined to the point where signal voltages about 100 dB below the transmitted pulse (or in the ratio of 1 to 100,000) can be detected. Thus echoes can be received not only from soft-tissue-to-bone interfaces, but also from many soft-tissue-to-soft-tissue and soft-tissue-to-fluid interfaces, which are usually not detectable by x-rays. This sensitivity, plus the ability to detect and localize radiolucent objects such as stones composed of uric or xanthic acids, wood splinters, etc., give ultrasonography a unique diagnostic capability. Also, unlike x-rays, the very low intensity sound waves used for diagnostic applications are completely harmless and have no restrictions with respect to the number of examinations or the areas which may be examined.

Ideally, this exploratory pulse signal is a single half-cycle of approximately one microsecond duration. In practice, the ultrasonic "bang" consists of a few rapidly decaying half-cycles. The pulses are produced at a repetition rate which may be varied from 200 to 1000 per second. Pulsing voltage, too, is variable from 1000 to below 200 volts, depending on the frequency used and on the material of the transducer.

To compensate for the attenuation of the signal caused by scattering and absorption in the tissues, an automatic sweep gain is usually employed so that the amplitude of the displayed echo signal is unchanged by the distance of the echo-producing structure from the skin surface.

Among the refinements introduced by manufacturers of ultrasonic diagnostic equipment is an electronic gating method which accepts echo signals only within a selected time span, thus controlling the depth of observation from the total thickness of the organism to a "slice" as thin as 2 mm anywhere along the beam's line of sight.

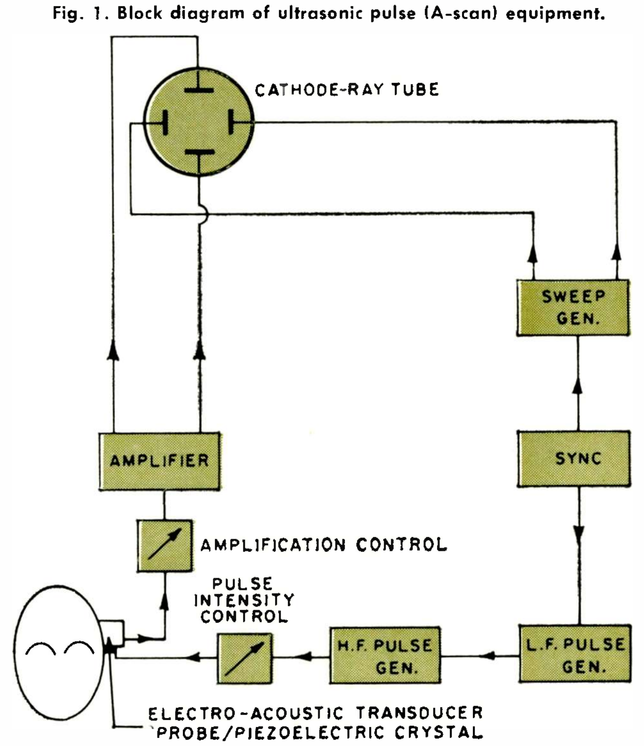
An exciting area for future development may lie in combining ultrasonic sonar techniques with color television. Interfaces reflect different ultrasonic frequencies to a different degree. If three different ultrasonic frequencies are directed at the same structure and pulsed in rapid sequence, echoes corresponding to the three frequencies and differing in their intensities can be used to modulate the three beams of a color television tube. The resultant color would be a visual representation of the reflectance of the scanned structure to the three selected ultrasonic frequencies. This technique, it is hoped, will produce an electronic "staining" which will allow interfaces of different structures to take on different colors depending on their nature.

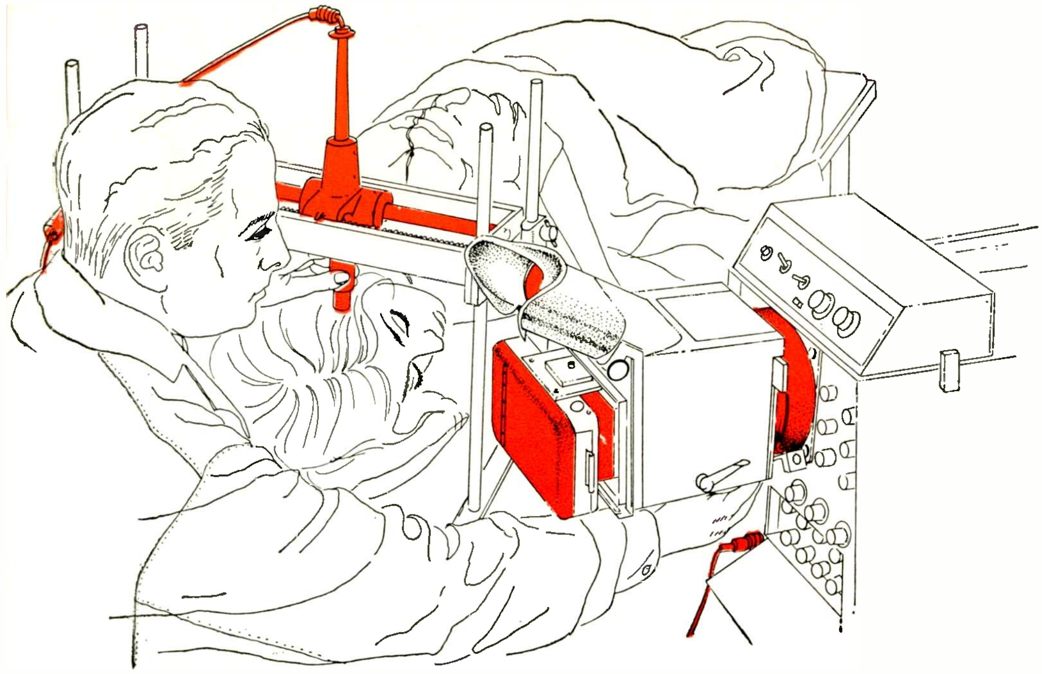
In the main, two principal ultrasonic diagnostic techniques have been developed: A-scan and B-scan (derived from designations of radar equipment adapted for the early experiments). The best-documented and the most widely used is the A-scan or time-amplitude ultrasonography. Another term suggested but not yet widely accepted is *stykographic* (from Greek "stykos," a line). In this type of examination the positions of the transmitting-receiving transducer and the echo-producing structure are fixed relative to each other. Echoes appear on the screen of a cathode-ray tube as vertical spikes along a horizontal time trace. Since the two-way speed of sound transmission through various tissues is known (about 13 μsec/cm in soft tissues), the horizontal trace can be calibrated in terms of the exact distance in tissue. A block diagram of a typical apparatus is given in Fig. 1.

In an adaptation of the A-scan technique used for observing moving or pulsating organs, such as the heart valves or blood vessels, the echoes produced by the moving structure are displayed as an array of scattered spots whose position corresponds to the motion of the structure. The addition of a slow 10-25 mm/sec vertical sweep converts the display to a waveform where the displacement is shown as a function of time.

The second major category of ultrasonic diagnostic techniques produces a B-scan. In this procedure the ultrasonic probe is moved in relation to the organ or area being examined

Fig. 1. Block diagram of ultrasonic pulse (A-scan) equipment.



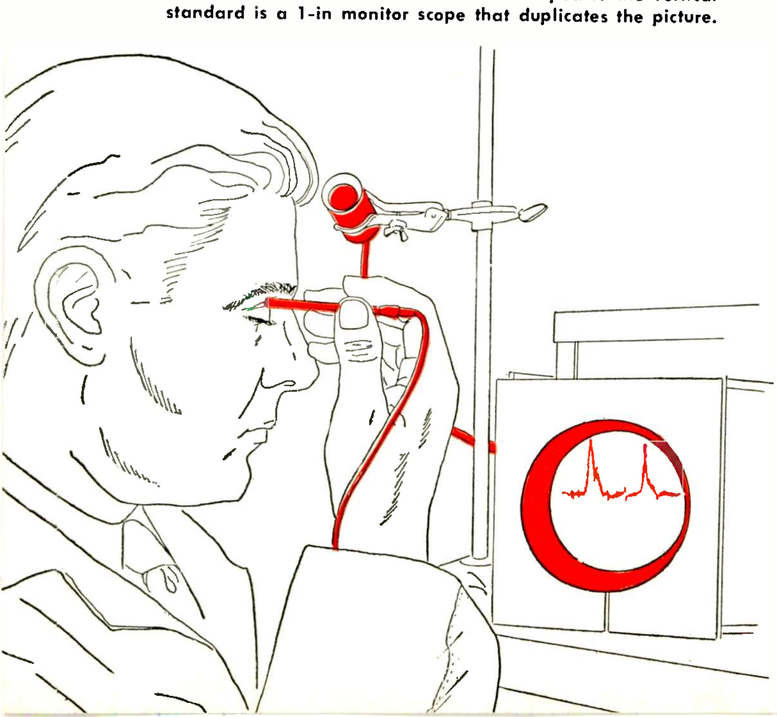


A transverse B-scan display of the head is being made here with Hoffrel Instruments equipment. The support bridge over the patient's head permits the ultrasonic transducer to be moved across head. Image is photographed from the CRT.

so that the array of echoes, displayed by intensity modulation on the long-persistence phosphor screen of a cathode-ray tube or integrated photographically, coalesces into an anatomical cross-section or "tomogram" in the plane sectioned by the sound beam. To obtain a more detailed anatomic outline, a so-called compound-scan technique has been developed where the transducer is moved in a combination of circular and rocking motion up to 360 degrees around the part being examined.

In the original compound scan experiments, the patients were immersed in a tub—part of a converted B-29 gun turret—of saline solution which acted as an acoustic coupling medium while the transducer carriage was rotated around the patient on a circular ring, at the same time oscillating in a 4-inch horizontal motion. This awkward technique placed a severe limitation on the usefulness of the procedure, but subsequently developed apparatus using portable mechanized scanners permits bedside examination of even very sick patients.

A pencil-type probe for surface application to the eye is shown being demonstrated. The left-hand pip on the scope is caused by the sound energy being reflected from the surface of the eyelid. The second pip is the echo from the back surface of the eyeball. The exact diameter of the eye can be measured from the horizontal scale. Clamped to the vertical standard is a 1-in monitor scope that duplicates the picture.



Application and Results

The A-scan technique has proved extremely valuable for several diagnostic applications. Probably the most widely used at present is the so-called midline echoencephalography used to detect space-occupying brain lesions by locating the position of the midline structures of the brain.

The brain is gelatinous and easily distorted. It is capable of sliding freely against the inner surface of the skull. Thin, strong membranes partly separate the two cerebral hemispheres and the cerebellum and restrain their movement. However, when a space-occupying mass such as an accumulation of blood (hematoma) or a tumor appears in one of the compartments, the brain is pushed away and herniates into one of the other compartments, carrying with it the internal blood vessels and displacing the midbrain structures. The direction and degree of this displacement are quickly measured by the displacement of the midline echo. This provides strong evidence of the existence of a space-occupying mass. Over 200 hospitals in this country and abroad are already equipped for this procedure. In several, echoencephalography is used as a routine screening of all suspected cases of head injury to determine whether a further and more elaborate study is indicated. Over-all accuracy in indicating the position of the cerebral midline for several thousand cases has averaged almost 95%.

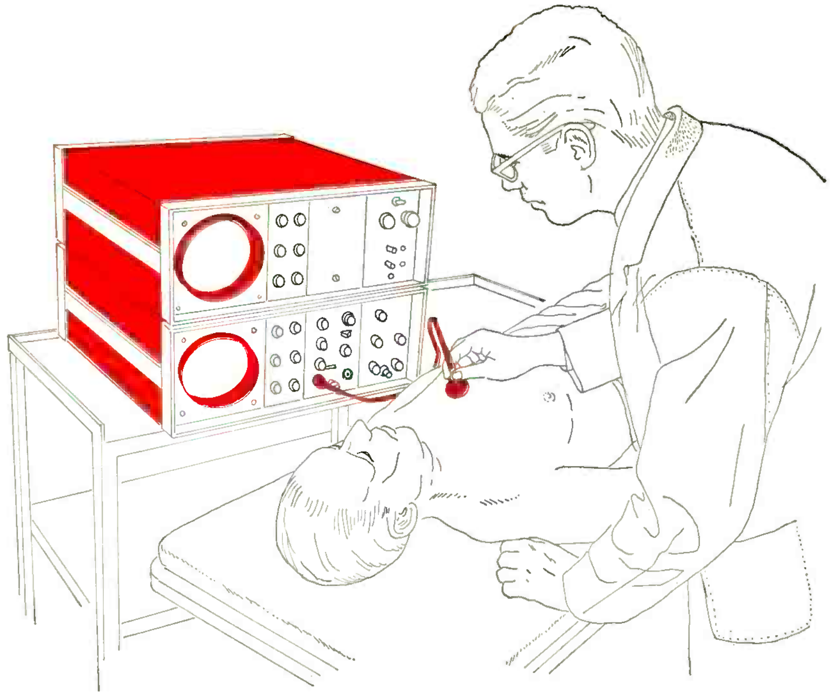
A rapidly growing application of echoencephalography is the diagnosis of hydracephalus. The swollen fluid-filled brain ventricles are easily measured with ultrasound and the condition of the patient can be conveniently checked by periodic examinations.

Experts foresee a military application of echoencephalography which will permit all cases of head wounds to be rapidly screened at the battle-line aid station with lightweight transistorized ultrasonic equipment to determine the seriousness and the subsequent management of the injury. Military medical researchers have also been successful in detecting and locating bone fragments by introducing a small ultrasonic probe into the wound itself.

A quite different use of the time-amplitude echoscan of the skull is to measure the diameter of the head of an unborn child. Measurements obtained by this method correlate within 2 mm with caliper measurements made after birth. The size of the fetal skull is important as a measure of fetal maturation and in cases of breech presentation. The amniotic fluid which surrounds the unborn child is a good acoustic medium. After the position of the fetal head is determined by palpation, the acoustic transducer is applied to the mother's abdomen. The position and direction of the sound beam is then adjusted until the echogram shows the echo of the infant's midbrain as well as the two stronger echoes of the two parietal bones. This assures that an exact right-angle measurement has been accomplished. X-ray measurements of the fetal head are not accurate because it cannot be determined with certainty whether a right-angle roentgenogram has been made. Also, because fetal tissues are particularly sensitive to ionizing radiation, repeated exposures to x-rays cannot be made with the same freedom as repeated ultrasonic scans.

One of the earliest applications of the x-ray was the location of kidney and gall stones. This can be done even more successfully with ultrasound, first, because ultrasound can detect stones which are composed of materials transparent to x-rays and, second, because ultrasound can be used both

B-scan ultrasonic examination can provide evidence of pregnancy. The outline of the fetal head is clearly shown here.



In this illustration, an ultrasonic heart examination is being performed with the aid of the diagnostic "Reflectoscope" manufactured by Sperry.

before and continuously during surgery. Using a variety of small transducers built into long thin probes and into flexible catheters, or clipped to the end of his finger, the operating surgeon can localize small stones hidden within ducts or on the underside of an exposed organ. In this way the located stones can be removed with the smallest possible incision and the least amount of damage to the tissues.

One of the first applications of an ultrasonic probe during an operation for the removal of an externally introduced foreign body took place in 1963. The case, described by Dr. Nathaniel R. Bronson of the Manhattan Eye and Ear Hospital, involved a four-year-old boy who had fallen on a pencil point so that a piece of graphite became imbedded in the upper cheek and remained there after the wound had healed. The case presented a special problem because the scar and the nature of the foreign body made it impossible to locate it precisely either with x-rays or by palpation. It was, of course, highly desirable to minimize surgical exploration and subsequent scarring.

After the piece of graphite was located approximately with an ultrasonic probe, an elliptical incision was made to include the scar. A one-eighth-inch diameter ultrasonic probe was then introduced into the incision and angled until an echo from the graphite located its position precisely and kept it in view during the operation. This proved a simple and easy method of maintaining visualization of the foreign body during surgery.

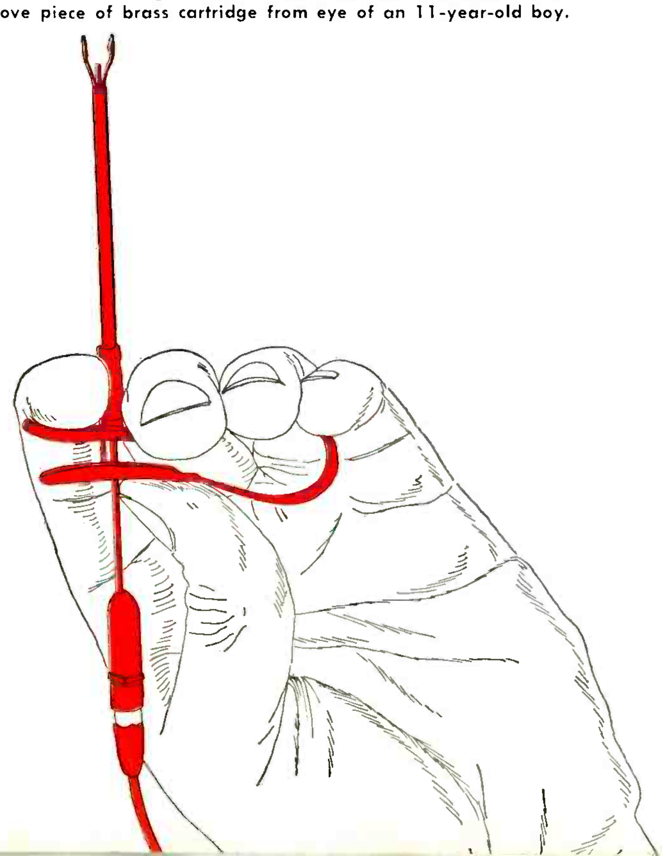
A very fruitful application of diagnostic ultrasound has been found for the examination of the eye. Ultrasound up to 15 MHz has been used by Scandinavian and American researchers to detect retinal and choroidal detachment in eyes obscured by cataracts or internal bleeding, to locate intraocular tumors, to measure the front-to-back diameter of the eyeball, and even to prescribe corrective lenses for aphakic (lensless) eyes of young children. A special ultrasonic transducer equipped with an acoustic lens can produce a sound wave beam less than 1 mm in diameter which is able to define intraocular structures less than 0.001 mm in diameter.

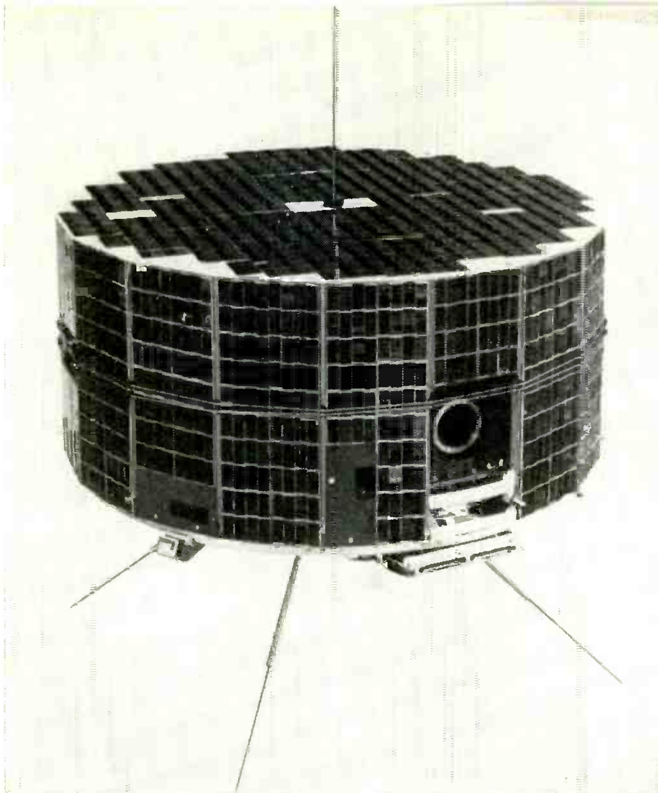
One of the most ingenious instruments recently developed for the extraction of foreign bodies from the eye is an intraocular forceps equipped with a needle-thin ultrasonic transducer. After the tiny instrument (originated by Bronson) is introduced into the eye, its position in relation both to the foreign body and to the back of the eye is continuously indicated on a one-inch display tube within the surgeon's field of view. In the first attempt last year to use the ultrasonically guided forceps, the time required to remove a piece of a brass cartridge from the eye of an 11-year-old boy was less than 40 seconds.

Many other applications of the ultrasonic A-scan include measurements of the diameters of the liver, spleen, and the bladder, the latter useful for the determination of the bladder capacity and amount of residual urine. Ultrasonic study of the heart has been used to obtain motion patterns of normal and diseased valves and blood vessels and also to diagnose pericardial effusion—a dangerous condition where fluid accumulates between the heart and the pericardium, the thin strong sack which encloses and protects the heart.

The B-scan technique, which produces cross-sectional tomograms, gives more definitive information of anatomical structures within the body but requires a much more sophisticated interpretation. A considerable number of animal and human studies have been performed to develop the technique and to relate the ultrasonic indications to actual anatomic conditions. Encouraging results have been obtained with examinations of the liver, kidney, and spleen. The normal tissue of these organs transmits sound well so that any pathological structure within them produces echoes, frequently characteristic of the type (*Continued on page* 62)

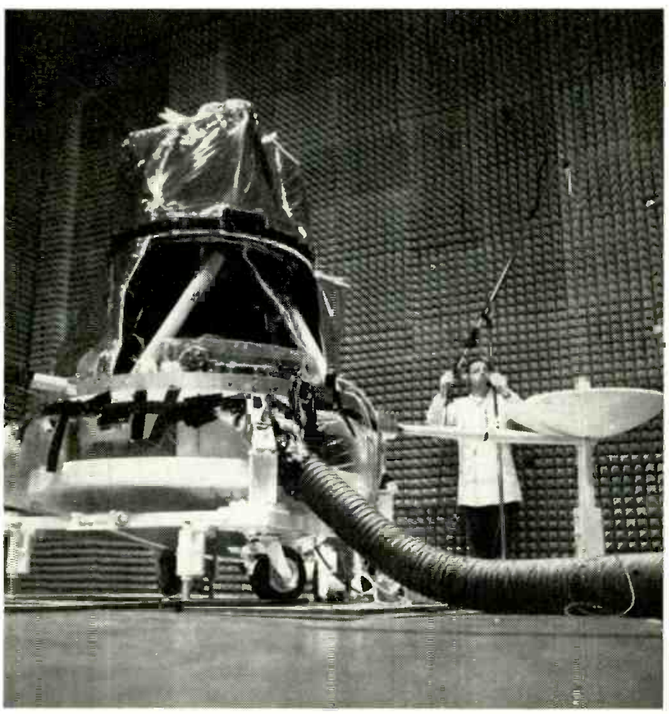
The Bronson foreign body locator and extractor used to remove piece of brass cartridge from eye of an 11-year-old boy.



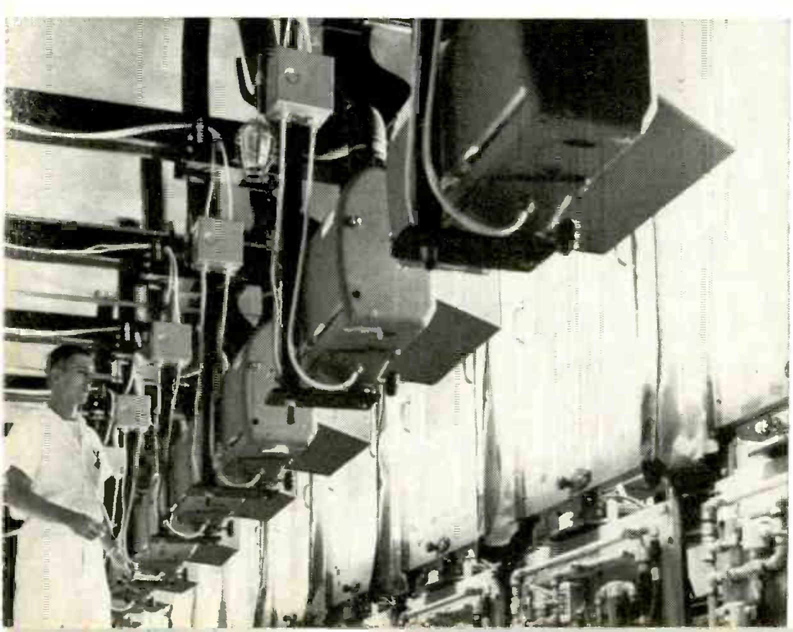


RECENT DEVELOPMENTS IN ELECTRONICS

First Global Operational Weather Satellite. (Above) Two Tiros operational system weather satellites have been launched for ESSA (Environmental Science Service Administration). One of these provides full coverage of the earth every day with weather TV pictures. The other provides local weather pictures to inexpensive receiving stations located throughout the world. Many nations will share the use of this satellite by employing simple, one-man ground stations. Any nation using one of these ground stations will receive two or three pictures of the user's local area per orbit on one to three orbits daily. Each picture embraces more than one million square miles. Integrated circuitry is used throughout the command system aboard the latter satellite, and it is believed to be the most extensive use of such circuitry in space to date. Ten previous Tiros weather satellites, all built by RCA, have been experimental or developmental in nature, but all have supplied useful weather data for many months. The last four satellites are still in operation.



Lunar Orbiter Electronics Tested. (Center) A Lunar Orbiter test spacecraft is shown here being tested in a microwave anechoic room at the Goldstone tracking station in the Mojave Desert. Later this year a flight version of the spacecraft will orbit the moon taking high-resolution photographs of possible landing sites for Apollo astronauts. A Boeing Co. engineering aide is shown picking up signals from the craft's antenna. These signals will be attenuated and transmitted several miles to an 85-foot antenna, where they are converted into light and recorded on film. The attenuation simulates the signal loss that would occur over the 240,000-mile moon-to-earth distance. The rubber spikes on the wall prevent unwanted reflection of signals. The 850-pound spacecraft is designed to dip within 29 miles of the moon's surface and take photos showing objects a yard square.



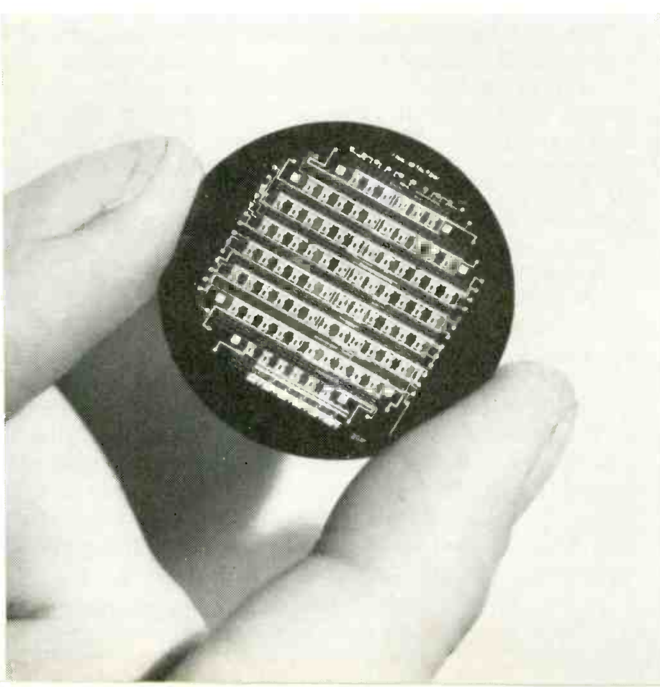
Color-TV Aperture Mask Production Tripled. (Left) The production of shadow masks for color-TV picture tubes is being tripled by Sylvania in order to meet the growing demands for this important component. A technician is shown monitoring a battery of printer units used for photographically imprinting patterns of the aperture mask on specially coated steel. This step in the manufacture of aperture masks precedes the chemical etching of up to 440,000 cone-shaped holes in each mask. The mask is later located just behind the phosphor-dot screen of the color tube. For each hole in the mask, there are three corresponding dots on the face of the picture tube consisting of red, blue, and green phosphors. The great public demand for color receivers is expected to continue in the future. In 1965, about 2.7 million color sets were sold to the public and it is expected that 4.5 million sets will be sold this year. In 1967, this figure is expected to increase to about 7.8 million sets, while over 8 million sets per year are expected to be sold through 1970.

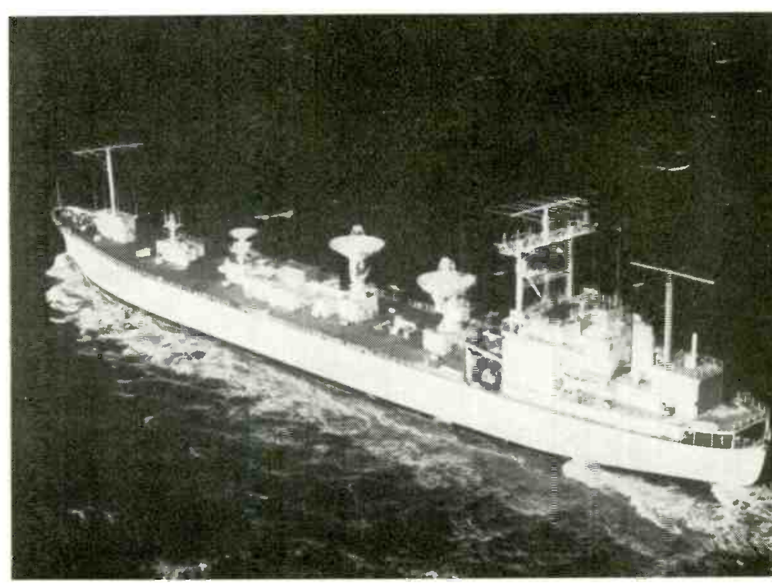
New Beacon Tracking Radar. (Right) Enclosed in the near pod under the fuselage of the aircraft shown here is a new K-band beacon tracking radar system. The system is designed to track and provide distance and angular measurements between aircraft carrying the radars and those carrying transponders. The radar uses all solid-state components with the exception of the transmitting magnetron and the local-oscillator tubes. Maximum range is 50 nautical miles, range-measuring accuracy is better than $\pm 0.1\%$ of true range, and angle-measuring accuracy is better than $\pm 0.25°$. The system was built for the Instrumentation Laboratory at Eglin Air Force Base by Airborne Instruments Lab.

Lightweight Microwave TV System. (Center) A laboratory model of a lightweight microwave communications system capable of short-range transmission of TV signals is shown. The low-power microwave beam is generated by a tiny microwave oscillating diode which is powered by a standard 30-volt battery. Together they represent about 1/50th the weight of comparable equipment presently used in commercial systems. The tiny gallium arsenide diode will provide at least one milliwatt of output power in the X and K microwave bands. It presently costs $150 each. The system was developed at the GT&E Laboratories.

Computer Interconnects Integrated Circuits. (Below left) Interconnections among the eighty circuits on this silicon wafer were produced automatically under computer control, in a new technique described by an IBM scientist at the recent International Solid State Circuits Conference in Philadelphia. After the circuits, each containing five transistors, have been formed on the wafer, an automatic device tests each of them and punches out results on punched cards. The cards are then fed into a computer which calculates an interconnection pattern that avoids any faulty circuits on the wafer and connects good circuits to perform the desired function. The actual connections are then "drawn" directly on the silicon wafer itself completely automatically under control of the computer.

First Apollo Instrument Ship. (Below right) Vanguard, the first of the Apollo Instrument Ships, recently completed her initial builder's trials in the Atlantic Ocean off Boston. The 595-foot vessel and her sister ships, Mercury and Redstone, will complement land-based tracking stations in our manned lunar exploration program. The three ships, created by cutting apart three World War II tankers and fitting them with new midbodies as well as the latest electronic tracking equipment, are being converted by General Dynamics. The dish-shaped antennas that are located on the deck include (left to right) one for C-band and two larger ones for unified S-band and telemetry work.





Comparison among the transverse, helical, and longitudinal techniques of recording TV signals with emphasis on the method used for home video recording.

By LEON WORTMAN / Ampex Corporation

The single-head full-helical video tape recorder may be employed to prepare training tapes for industry or for schools.

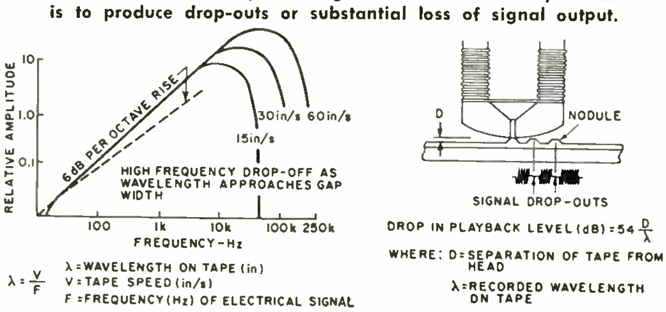
Video Tape Recording Methods

THERE are two basic formulas in the magnetic recording field which represent the major stumbling blocks against storing television signals on tape. The first formula has to do with the recorded wavelengths which are proportional to the velocity of the tape over the frequency to be recorded (Fig. 1A).

With normal audio signals, which extend to 15 or 20 kHz, the recorded wavelength on tape turns out to be a reasonably manageable dimension, but television frequencies extend more than a hundred times beyond. Something must be changed to accommodate this spectrum of frequencies, and the original approach was simply to increase the velocity of the tape so that the wavelength on the tape remained a workable magnitude. The early experiments conducted in the late 1940's by *RCA* and others were in this direction. Huge reels spewing incredible amounts of tape past stationary heads yielded the first visible images, but the efficiency of such systems was too low to make them practical.

The second formula has to do with signal level in relation to head-to-tape contact. This one says that signal loss is proportional to 54 dB per wavelength separation between the head and the tape (Fig. 1B). If the wavelengths are very small, then the head had better remain in more intimate contact with the tape to retain the few millivolts available in playback.

Fig. 1. (A) Response of a tape playback head at various tape speeds, assuming equal recorded flux density on tape at all frequencies. When head gap is equal to one-half the recorded wavelength, output is maximum; when gap width equals recorded wavelength, output drops to zero. (B) The effect of tape-surface imperfections preventing intimate contact of tape head is to produce drop-outs or substantial loss of signal output.



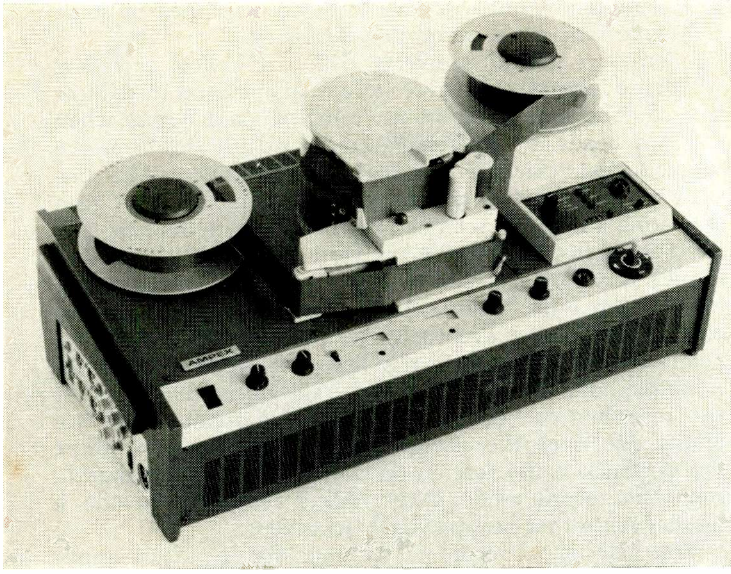
The logical solution to these two dilemmas is first to achieve the high writing speed necessary by rotating the head assembly, rather than accelerating the tape and, second, allowing the head to penetrate or intimately contact the tape (which should be free from imperfections) as it scans the video tracks. Having met these requirements, we are now faced with the problem of how to physically scan the tape.

Transverse System

There are a great number of recording techniques which must be considered before a commercially acceptable system is adopted. Each method yields some measure of performance and each has advantages and disadvantages. Some of the methods which have been attempted include small arcuate, large arcuate, spiral, full-helical, half-helical, and transverse.

The first commercially successful video recorder, which employed the transverse system (Fig. 2), was introduced by *Ampex* in 1956 at the National Association of Broadcasters Convention in Chicago. This recorder utilized a rotating head assembly (14,400 rpm) approximately 2" in diameter, with four transducers peripherally displaced by 90 degrees. The 2"-wide tape moved at 15 ips and the transverse tracks laid down were 10 mils wide at an angle of 89.7 degrees, virtually perpendicular to the edge of the tape. Audio and control-track signals were recorded along the edges of the tape in normal longitudinal fashion.

This transverse system has since been developed into the most sophisticated technique for recording monochrome and color-TV signals on tape. Accessories to the system permit its use for complex program production, editing, animation, and dubbing. Color recording of NTSC signals (the most difficult to handle) can be made, dubbed, or reproduced with a quality virtually indistinguishable from a live color program. The standards adopted for this system were universally accepted. Virtually all 4-head transverse recorders make interchangeable tapes.



A typical two-head half-helical scan video tape recorder.

The major drawback to this system is its complexity and price. All of these recorders, even in their simplest configuration, lie above the $20,000 mark and a fully equipped color machine runs closer to $100,000.

Once the feasibility of committing video signals to tape was established, laboratories throughout the world started attacking the problem with new vigor in an effort to reduce the size, complexity, and cost of this type of equipment.

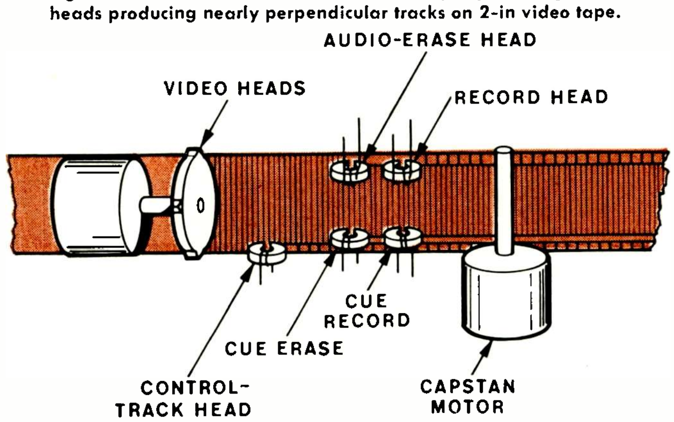
From the early 1960's, there has been a continual parade of new entries into the field and a proliferation of standards that eliminated interchangeability among manufacturers as a basic requirement. The systems that have emerged are the full-helical, the half-helical, and the longitudinal.

Full-Helical System

The full-helical system utilizes a single transducer on a drum around which tape is wrapped on a scanning assembly (Fig. 3). The tracks are laid down at a slight angle to the edge of the tape, running from one edge to the other. Audio and control tracks (not shown) occupy narrow spaces near the edges of the video tape. The tape may be wrapped around the helical assembly in three ways.

At the crossover point, where the rotating head completes one track at the bottom edge and starts the next track at the top, the tape may be either overlapped, butted, or separated in an *omega* form. All of the methods will work. However, the *omega* appears to be the most practical since the entry and exit gates support and position the tape more accurately and the crossover period may be kept to a minimum. The simplicity of the full-helical system is in its need for only a single transducer to perform the video recording

Fig. 2. The transverse recorder uses four rapidly rotating video heads producing nearly perpendicular tracks on 2-in video tape.



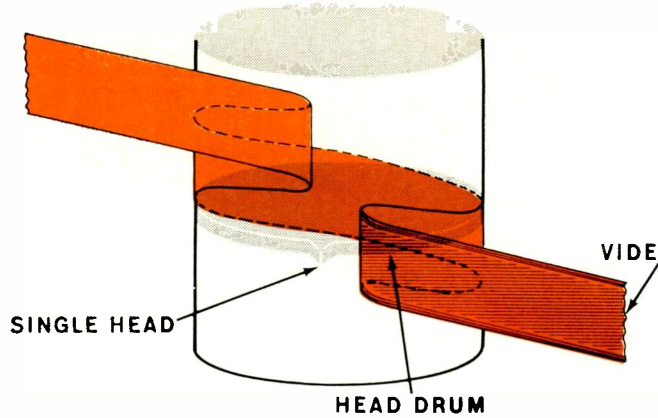


Fig. 3. In the full-helical recorder, a single rotating head is used and tape is wrapped almost completely around drum.

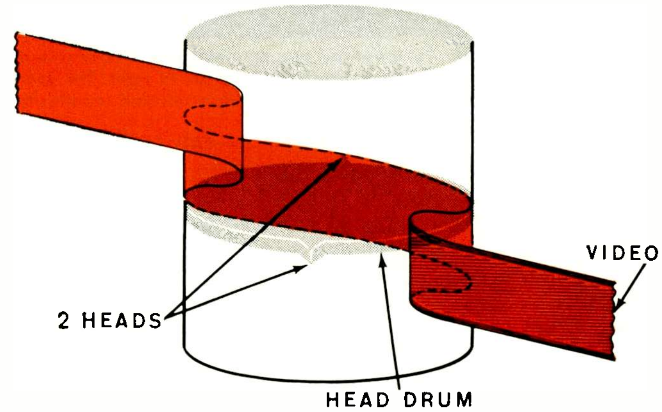


Fig. 4. In the half-helical recorder, two rotating heads are used and tape is wrapped a little over half way around drum.

function. In this way, there is no necessity to match heads, to worry about relative electrical characteristics, and geometric displacement.

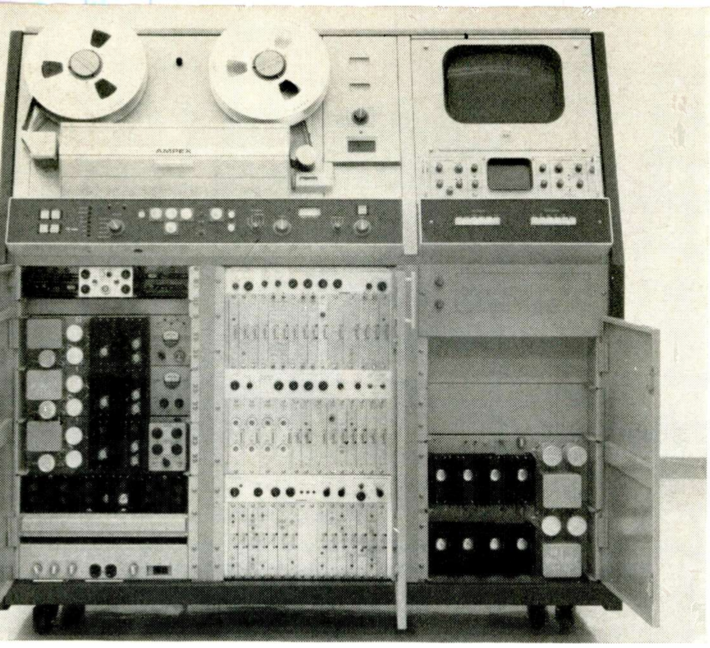
It does, however, have one major drawback. No matter what technique is used, the head must leave the tape for a short instant of time and during that period no signal will be available. This is known as the drop-out period and is usually located somewhere near or in the vertical interval so that it will disturb the image as little as possible. The signal, of course, may be blanked during this time by applying some sort of clamp, but if the television system requires continuous availability of synchronizing and blanking pulses, then some complex regeneration is necessary to reintroduce such pulses during this drop-out period. If the phase of the incoming signal changes during recording, then a black bar will run through the picture until the recorder catches up with the new phase. This would almost preclude such a recorder being used for any broadcast applications without a processing amplifier. This is the system employed in the manufacturer's home video tape recorder.

Half-Helical System

On the principle that two heads are better than one, the half-helical system retains some of the simplicity and eliminates many of the drawbacks of the single-headed arrangement (Fig. 4).

As implied by the name, the half-helical wraps the tape around the scanning assembly for a little more than 180°. Two head transducers on the drum now scan the video signal with sufficient overlap so that electronic switching will permit sequencing the signals from tape into continuous form with only the switching time transient from one head to the next. The switching transfer can be inserted during vertical blanking and would be invisible on a normal monitor.

There are some peripheral advantages. The tape is in



Video tape recorder for broadcast use, employing transverse recording system. Waveform and picture monitors are at right. The doors have been opened to show modular construction and complexity.

contact with the scanning assembly for only half the distance, thereby reducing the effects of "sticktion," a term describing the cohesion between the surface of the scanning assembly and the face of the tape. The differential stretch is kept to a minimum and the scanning angle is increased to accommodate the shorter path.

These recorders can be broadcast-stabilized and some have been fitted with versions of electronic editing that permit inserting or assembling sequenced video information without disturbances to the playback image. The best time-base stability of both types of helical recorders is limited by the inertia of the larger drums and the complexity of attempting to control such a mass of moving metal. Recording and playback color signals (requiring high time-base stability) cannot

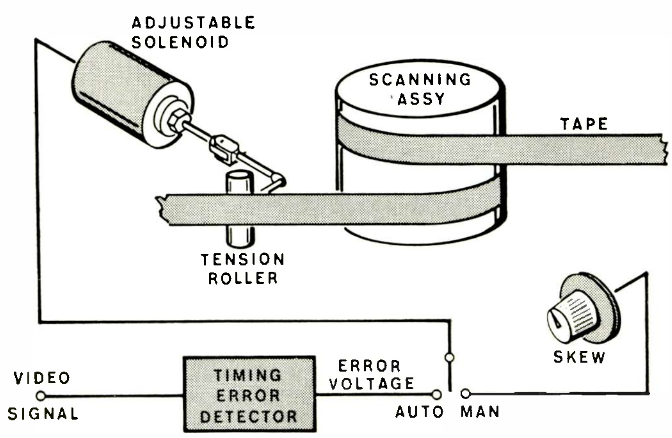


Fig. 5. Automatic tension servo employed when the half-helical video tape recorder is designed for broadcasting applications.

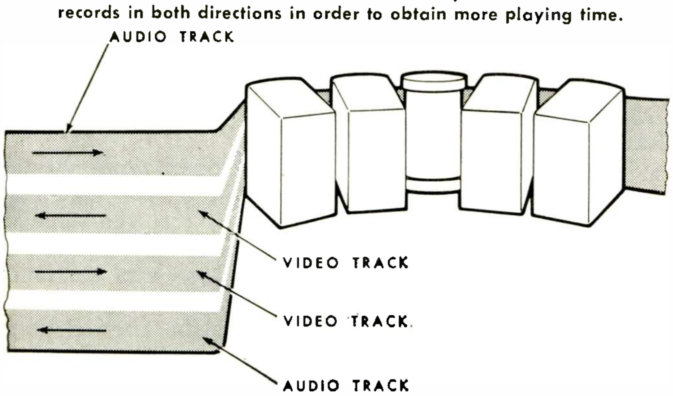


Fig. 6. Longitudinal recorder uses stationary video heads and records in both directions in order to obtain more playing time.

be done directly, but will have to be accomplished by some electronic time-based stabilizing accessory.

There are several problems with half-helical recorders which are inherent whenever more than one head transducer is used. The first is known as "dihedral" and occurs when the two heads are not displaced by exactly 180° on the drum. An interchanged tape being played back will be misread in time by the alternate head assemblies, one scan appearing a little too soon and the other a little too late. The effect is the displacement of any vertical line to the right and the left of where it should be at the top of the image on the television monitor. The flywheel effect of the horizontal circuit on the monitor eventually averages out the line, so the defect is only visible for a few lines after vertical blanking. A simple adjustment of the head transducer position and a test recording can correct this fault. Temperature and humidity effects on the elasticity of the tape will also affect the playback if the tension on the tape has varied slightly from the record mode. Most helical recorders include a tension control for best playback conditions.

The half-helical recorders designed for broadcast applications require an automatic system to do this and a tension servo (Fig. 5) is used. This device develops an error voltage from the timing error between alternate fields and applies this error voltage as a correction to a solenoid controlling a tension roller against the tape. It is possible to achieve a degree of correction which limits the transfer time-based displacement to less than approximately 0.25 microsecond, a figure well within broadcast requirements.

Longitudinal Recorders

There has been a great deal of publicity about the advent of a longitudinal video recorder which would be cheaper and simpler than a machine with the rotating-head approach. These recorders all work on the principle of an audio recorder, using extremely narrow-gap heads with very rapidly moving quarter-inch tape. Tape speed is on the order of 100 ips and even at this great velocity, only 1.5-MHz bandwidth is achieved.

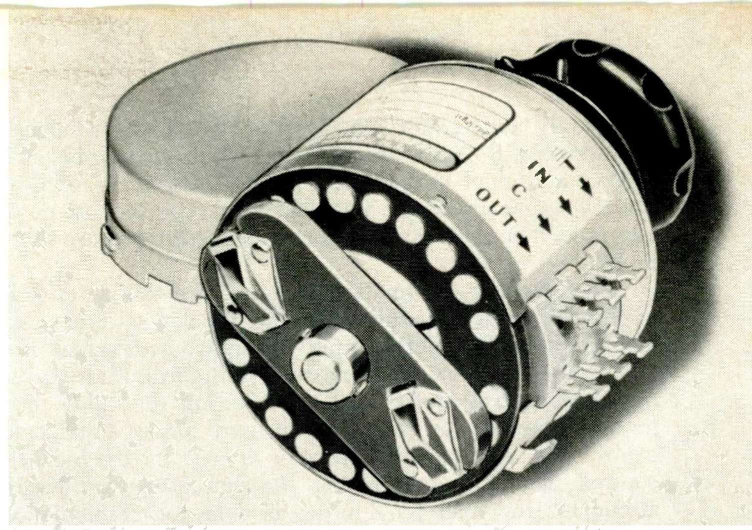
The thinnest tape on the largest practical size reel will only yield about 30 minutes of playing time per direction. Both forward and reverse tracks are recorded, doubling the playing time with the reversal of the tape. Audio tracks are also recorded longitudinally along with the video signal.

There are a number of inherent drawbacks in this type of approach. Primarily, the picture quality is poorer than that of the helical recorders because the active read/write speed is limited by the tape-handling capabilities of the transport. At 100 ips, the problems of spooling tape, handling it safely, and avoiding tape throw are severe. Small discontinuities on the oxide cause tape lift with subsequent streaking in the picture. Special pains must be taken to keep the tape surface very smooth.

Although the longitudinal recorder would seem to be the simplest approach, it still represents a considerable degree of complexity over an ordinary audio recorder and the results obtained usually fall below those required for most picture image storage purposes. *(In spite of this limitation, picture quality may be adequate for non-critical home use, especially in view of the fact that such units may be made at a lower price than rotating-head machines.—Editor)*

Video recording on magnetic tape divides into three levels at the present time: home recorders, ranging in price up to $1500; industrial and educational recorders up to $15,000; and a fully broadcast-compatible transverse machine that was previously described, at up to $100,000. The application of the small recorders is virtually limitless for in-home entertainment, sports, education, medicine, and travel. Magnetic TV recording represents, at the present time, one of the greatest potential fields for electronic equipment and, in a few years, will be almost as universal as television itself. ▲

Circuitry, design, and selection of these devices which vary signal levels without disturbing the impedance, frequency response, or other system characteristics.



A typical unbalanced bridged-T variable resistive a.f. attenuator.

By CHESTER F. SCOTT
Chief Engineer
Daven Division, McGraw-Edison Co.

RESISTIVE ATTENUATORS and PADS

THIS article covers the circuitry and design of resistive attenuator networks. These are used to vary signal levels without disturbing the impedance, frequency response, or other characteristics of the system. They are referred to by many names such as faders, pads, mixers, masters, pots, etc., but the basic function remains the same.

Attenuator Classifications

Attenuators are divided into two main classifications: *fixed* and *variable*. Fixed attenuators are used where the level of a signal must be reduced by a known number of decibels which will not have to be changed. Variable attenuators are used where rapid or frequent changes in signal level are required. They are also used when the required amount of signal reduction must be determined at the time of system installation. Where frequent variations in level are necessary, an attenuator which is variable by a rotary or a straight-line switch is used. When the level can be adjusted and set with a minimum of future changes, a type that is variable by means of soldered interconnections is normally used.

The basic circuits for both the variable and fixed types are the same and the formulas for resistor values are equally applicable to both. In variable attenuators which are controlled by a switch, the variation is generally accomplished by adding or subtracting resistors in the series and shunt circuits. The exceptions are the ladder and π types. In the ladder type, all resistors are fixed and the series resistor tapped at correct intervals. The π operation is covered later. *(Inexpensive variable attenuators are also available in which the various series and shunt elements consist of volume-control-type potentiometers that are ganged together to produce the proper resistance changes as the control is operated—Ed.)* Attenuators that are variable by means of changing soldered interconnections consist of a group of fixed pads with different attenuations. The attenuation variation is accomplished by connecting attenuators with the correct losses in series to provide the required total attenuation.

Electrically, attenuators are divided into two main classifications: *balanced* and *unbalanced*. A balanced attenuator control is one where equal resistance is inserted in each side of the circuit and where the center point of any shunt resistance can be grounded or left floating depending upon the other circuit characteristics. An unbalanced control is one where the resistance is added in only one side of the line and where the other side of the line is "common" or grounded.

In designing the equipment where attenuators are to be used, there are two schools of thought as to whether balanced or unbalanced controls are more satisfactory. One group claims that balanced circuitry is better because hum and noise due to ground loops and improper grounding is done away with. The other group contends that unbalanced circuitry is better because, with proper grounding, stray capacities are overcome and better control is obtained. This article will not attempt to deal with the merits of over-all system design. There are instances where economics will be a determining factor in system design, and we will only indicate that balanced controls are usually approximately twice as expensive as their unbalanced counterpart since twice the number of resistors and twice the switch facility are required.

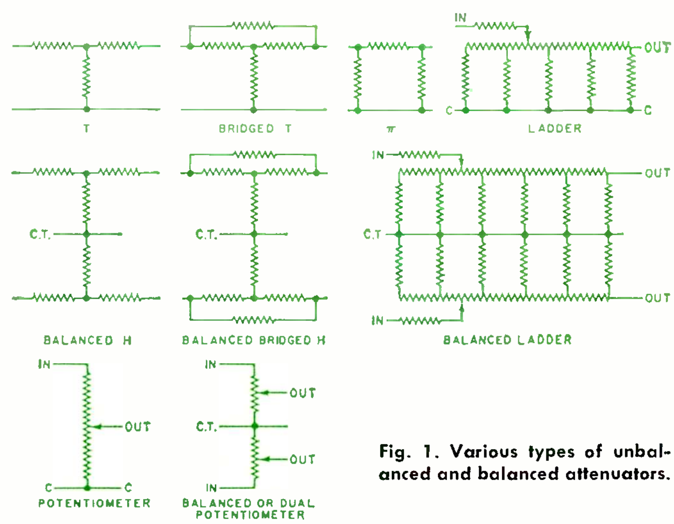


Fig. 1. Various types of unbalanced and balanced attenuators.

An unbalanced control cannot be used where other circuitry is balanced because, to operate correctly throughout the required frequency range, an unbalanced control must have one side of the line grounded. A balanced control cannot be used in an unbalanced circuit since ground on one side of the unbalanced circuit would affect the control operation. One-half of a balanced control, *i.e.*, one input terminal, one output terminal, and the center-tap terminal, can be employed in an unbalanced circuit but only if the particular circuit impedance is one-half that of the balanced control.

The most frequently used attenuator circuits are the T, bridged-T, ladder, and potentiometer types or their balanced counterparts, the balanced-H, balanced bridged-H, balanced ladder, and dual or balanced potentiometers. In high-frequency applications, the unbalanced π type is most generally used. The schematic diagrams for these types are shown in Fig. 1.

The following information covering the design and use of the various styles is given for the unbalanced types only. The formulas for determining the resistance values in a balanced control are the same as those indicated for the unbalanced control except that, in inserting the value for Z in the formula, the full value is used for an unbalanced control but only one-half the value is used for the balanced control. Thus, in determining the values for a 600-ohm attenuator, the value for Z in the formulas for an unbalanced control is 600 ohms, but that for a balanced control is 300 ohms.

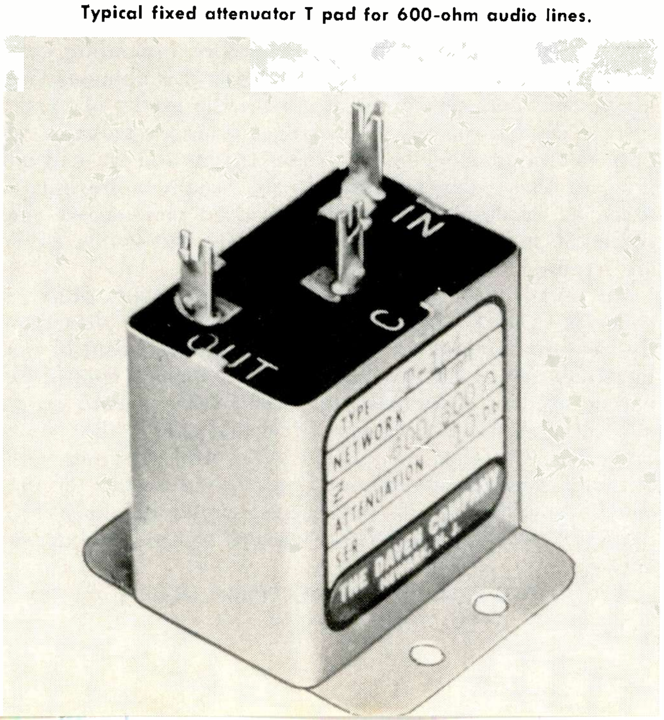
The T attenuator is generally the most stable and, within reasonable limits of terminal impedance and range of attenuation, can be made the most accurate through fairly wide frequency ranges. Since it requires three variable resistors and their associated switching, it is generally the most expensive of the unbalanced types used at frequencies up to 1 MHz. Both the input and output impedances remain constant, within the specified resistor accuracy, throughout the attenuation range. The insertion loss of this type control is zero dB when the input and output impedances are equal.

These characteristics make the T attenuator especially useful as controls in instruments and other applications where accuracy and constant impedance are required. The formulas for determining the resistance values required are shown in Fig. 2A.

Where equal input and output impedances are involved, Z_{in} and Z_{out} are equal and the resulting values for *R*1 and *R*2 are also equal. For a fixed-loss attenuator with either equal or unequal input and output impedance, and for a variable loss attenuator with equal input and output impedance, the formulas are used without further consideration. For a variable loss attenuator with unequal input and output impedance, the resistor values are normally determined for one impedance, and an impedance-matching network is used to match the impedance at the other end. The resistance values for this impedance-matching network are determined as indicated later in this article.

The bridged-T network is a variation of the T network which requires the use of only two variable resistors. It is thus somewhat less expensive than the T but has practically

Typical fixed attenuator T pad for 600-ohm audio lines.



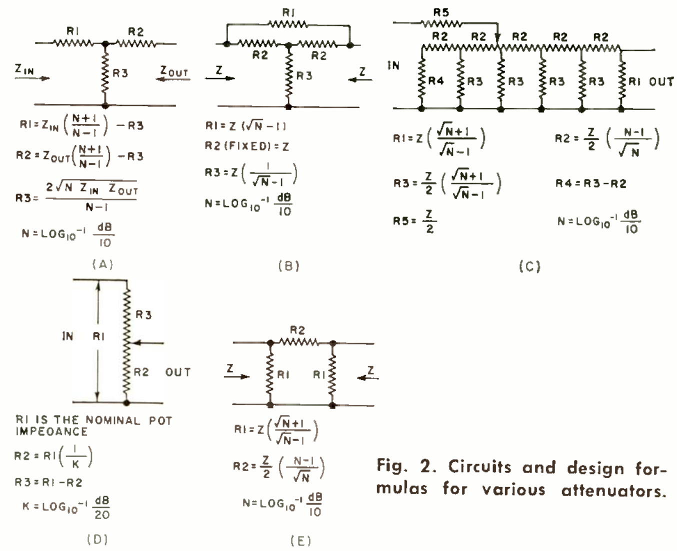


Fig. 2. Circuits and design formulas for various attenuators.

equal characteristics up to somewhat lower attenuation values. The bridged-T has a constant input and output impedance throughout the attenuation range and has a zero dB insertion loss when the input and output impedances are equal. In the higher losses above 30 to 40 dB, the value for *R*1 (see Fig. 2B) becomes so high that it is more susceptible to the effect of any stray capacitance across it.

The bridged-T attenuator is normally used only for attenuators which are variable by means of rotary or linear switching. They are normally used between equal input and output impedances but, with the use of an impedance-matching network at one end, they can be used between unequal impedances with the necessary insertion loss due to the impedance match. They are used mainly in instruments or in communications equipment where constant impedance and zero insertion loss is important and where the attenuation range is not too great. The formulas for determining resistance values are shown in Fig. 2B.

Ladder Attenuators

The ladder type attenuator is actually a variation of the π type and is used only in the variable loss styles. It requires the use of only one variable resistor and is the least expensive of all the types except the potentiometer. Ladder attenuators are most generally used as mixer controls in public address systems and broadcast consoles, and also as controls in audiometers.

The circuitry is such that the output impedance falls to about two-thirds of the nominal value at the low loss end and the input impedance falls to approximately the same amount at the high attenuation end. The curves for a 30-step, 1½ dB/step ladder with a 600-ohm input and output impedance are shown in Fig. 3. Throughout the mid-attenuation range, where the control is normally operated in mixing applications, both the input and output impedance are fairly constant and practically nominal.

The resistor values in a ladder attenuator are such that they remain within practical limits throughout the attenuation range. Thus, the high attenuation values required for audiometer applications are obtainable in a single control. With an equal input and output impedance, the ladder attenuator has an insertion loss of 6 dB. This is partially due to the fact that, unlike a T or bridged-T attenuator, all the resistors of the ladder attenuator are in the circuit at all times and control is obtained by connecting to various taps on the series resistor by means of the switch. The remainder of the insertion loss is due to the fact that a resistor, equal in value to one-half of the input impedance, is connected in series with the input to provide a more constant impedance. When the input impedance of a ladder attenuator is one-half of the output impedance, the resistor in series with the input is omitted and the insertion loss is approximately 2dB.

The ladder attenuator is unique because its circuit is such that any possible switching noise is attenuated along with the signal. This feature is helpful in mixer applications where the signal-to-noise ratio is especially important. The formulas for the resistor values in the ladder attenuator are shown in Fig. 2C.

For optimum decibel and impedance accuracy, dB in the formula is normally selected as 6 dB. For a 2 dB per step control, $R2$ is tapped for three equal sections and for 1½ dB per step it is tapped for four equal sections.

Potentiometers and π Networks

The potentiometer is a simple potential divider and is designed to operate into a very high impedance such as the grid circuit of a vacuum-tube amplifier. It is used to control voltage in specific decibel steps or in special voltage ratio steps. It has the simplest construction and is therefore the least expensive of any of the attenuators. The formulas for determining the resistor values for this attenuator are shown in Fig. 2D.

The formulas are for potentiometers calibrated in decibel steps. When voltage ratios are required, the ratio of $R2$ to $R1$ is the same as the ratio of the required output voltage to the input voltage. Again, $R3 = R1 - R2$.

The π network is comparable to the T network in stability and accuracy. It is also a network which requires three variable resistors. It is not generally used in low- and medium-frequency variable attenuator applications because the switching is somewhat more complicated than that for the T network. It is more generally used in high-frequency attenuators because it is easier to shield and the resistor values are in a range more readily adaptable for the lower impedances used.

In the high-frequency variable attenuators, the variation in attenuation is accomplished by switching π attenuators of the correct loss in and out of the circuit. For this type of switching, the resistors values in a π network remain within a range which is not overly affected by stray capacitance. The formulas for the π network are shown in Fig. 2E.

Attenuation Per Step & Matching

The selection of the dB per step of any attenuator depends upon the usage. For controls used in instruments, the dB per step can be any value up to 10 dB, and sometimes more, depending upon the instrument requirements. In broadcast and recording operations, the normal maximum dB per step is 2.

In the higher quality recordings, no switching noise can be tolerated. If the dB per step is too high, there will be a noticeable "pop" if the control is switched between steps during a sustained note. The lower the dB per step, the more steps are required to obtain a comparable total attenuation and more steps means higher cost. Thus, economics enters into the choice, but in recording applications, steps of 1.5 dB or less, if practical, are commonly used.

For optimum over-all operation, the impedance of all portions of a system should match. Thus, with the exception of the potentiometer, the input impedance of the attenuator should equal the impedance of the source and the output impedance of the attenuator should be equal to that of the load.

When the source and load impedances are unequal, a resistive network can be utilized to match them. This impedance-matching network is generally a T network or its counterpart, the balanced-H. Where a resistive network is used to match unequal impedances, some loss is necessary. The amount of this loss is dependent upon the ratio of the higher impedance to the lower impedance being matched.

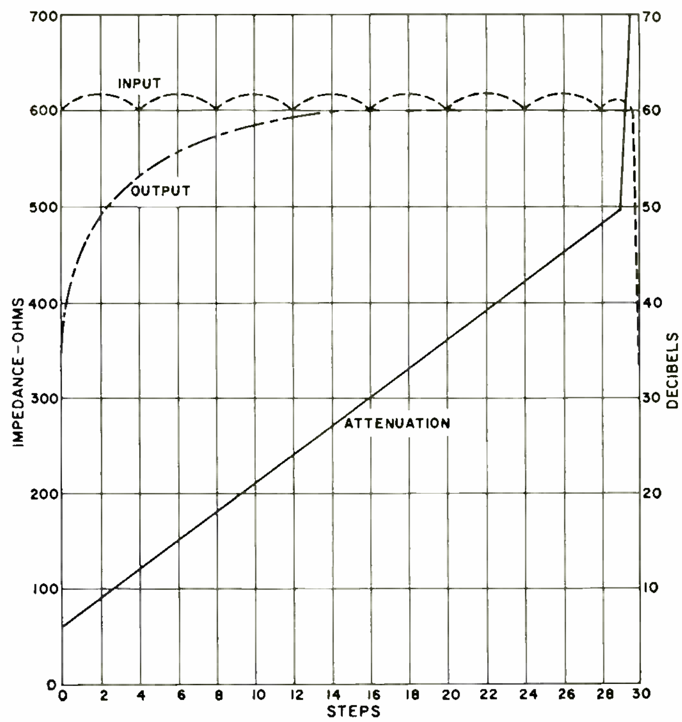


Fig. 3. Characteristics of a 30-step ladder attenuator.

Power & Impedance Available

The normal power dissipation of most attenuators is 0.5 or 0.6 watt continuous. Such attenuators will handle up to approximately 2.5 watts peak in audio circuits where the level fluctuates considerably. Attenuators with continuous power rating up to 20 watts and, in special cases, higher are available. Attenuators which have a low dB loss, such as decade T types with 10 steps of 0.1 dB per step, can be used in circuits where the wattage is considerably above the normal rating of the control. This is due to the fact that only a relatively small portion of the power is dissipated in the attenuator whereas most of the power is dissipated in the load.

In general, balanced-H, T, and ladder attenuators are available with impedances up to about 1000 or 2000 ohms. For special applications, controls with higher impedances are obtainable but attenuation and frequency ranges must be considered since internal capacitance and capacitance in the external wiring will have greater effect on the attenuator accuracy. The attenuators used in high-frequency applications generally have an impedance of 50, 52, 73, or 75 ohms. Attenuators with 93- and 125-ohm impedances can be made but, for a specified accuracy, the frequency range is limited by capacitance effects. Potentiometers normally are made with impedances in the range from 1000 ohms to 1 megohm. Lower impedances are available with a somewhat reduced attenuation range due to resistance values becoming too low for practical manufacture. Capacitance effect becomes a limiting factor for impedances over 1 megohm.

Attenuation & Frequency Range

The attenuation range available in an attenuator depends upon impedance, circuit type, and frequency range. In bridged-T and bridged balanced-H attenuators the variable series resistor becomes exceedingly high at the higher losses and the variable shunt resistor becomes too low for practical manufacture. Thus the highest loss normally supplied in the bridged-T and bridged balanced-H types is approximately 40 dB. This is not a firm figure because impedance and dB per step must be taken into consideration.

In T and balanced-H attenuators the limiting factor on the dB range is the resistor value between steps in both the series and the shunt arms. (*Continued on page* 79)

AUTOMATIC

TV Brightness Control

By STU HOBERMAN

A photocell can be used to control the bias on the CRT to change TV picture brightness with room light changes.

AUTOMATIC brightness control circuits that monitor the ambient room lighting and adjust the cathode-ray tube brightness accordingly are being used in a number of black-and-white sets.

The heart of these circuits is a tiny device called a photocell. It can be considered as a variable resistor that changes its resistance value in proportion to the amount of light striking its sensitive surface. When the photocell is in darkness, its resistance may reach several megohms, while under a bright light, the resistance can drop down to about 100 ohms. These values depend largely on the construction of the cell, the size of the sensitive surface, and the chemical composition of the cell.

Fig. 1A shows the response of a typical cell to the light spectrum. Note that, like the human eye, this particular cell is responsive to the visible portion of the light spectrum from about 5000 to 7000 Å. Specially designed photocells that peak in the infrared or ultraviolet regions of the spectrum are available.

How the photocell responds to varying degrees of light intensity is shown in Fig. 1B. The photocell used here is an *Amperex* type RPY-17 that varies its resistance from almost 100,000 ohms at .1 footcandle to about 100 ohms at 1000 footcandles.

Because of the response characteristics, photocells may be used in many applications where control circuits must imitate the response of the human eye. One such application is in the automatic brightness circuits where the photocell will control the brightness of the CRT in response to changes in the viewing room illumination.

Fig. 2 illustrates basic operation of the automatic brightness circuit. The photocell (*PC*1) and the range adjust (*R*6*A*) are added for automatic operation. The contrast control is shown as part of the video amplifier circuit, with the video signal applied through a voltage-divider network to the cathode of the CRT. The d.c. level of the signal at the cathode is determined by the brightness control. Decreasing the level results in a brighter picture, while increasing the level results in a darker picture.

To modify the basic circuit, the photocell and range adjust are added as shown in Fig. 2. Photocell *PC*1 is part of a voltage-divider network that includes *R*6 and *R*6*A*. The voltage applied to this network is tapped off by the wiper arm of *R*6 and applied to the cathode of the CRT through *R*5. Rotating *R*6 wiper towards *R*6*A* lowers the cathode bias to increase brightness. Moving *R*6 wiper the other way makes the cathode more positive and lowers the CRT brightness.

Potentiometer *R*6*A* functions as the range adjust control and limits the maximum resistance of the circuit. The voltage at the lower end of *R*6 is then a function of the setting of *R*6*A* and the resistance of *PC*1. If the room illumination increases, the resistance of *PC*1 decreases, lowering the d.c. level and increasing CRT brightness. The reverse situation occurs when the room is darkened.

To make the modification, disconnect the ground side of the brightness control and connect a 100,000-ohm potentiometer (*R*6*A*) between the open leg of the control and ground. Clockwise rotation of *R*6 and *R*6*A* must result in an increase in CRT brightness. Wire one leg of *R*6*A* to the wiper arm so that clockwise rotation brings *R*6 closer to ground.

Connect the photocell (*PC*1) across *R*6*A* as shown, and mount the cell through a cutout in the front of the TV set so that the cell can monitor the room illumination. ▲

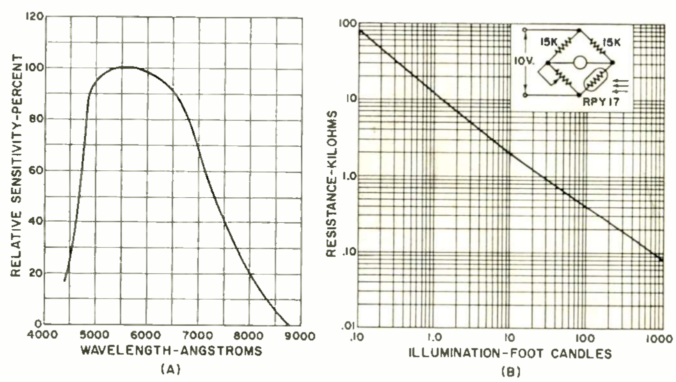
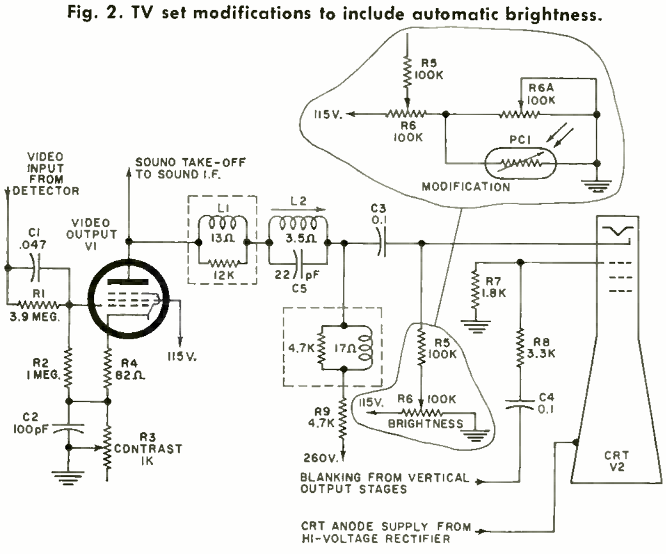


Fig. 1. (A) Plot of typical photocell response across the light spectrum. (B) Photocell resistance varies with light.

Fig. 2. TV set modifications to include automatic brightness.



Our author began his professional career at the Harvard Underwater Sound Laboratory in 1943. From the end of the war until 1949 he was Assistant Professor of Engineering Research at the Pennsylvania State Univ. and a Group Leader of Electronic Research at the Ionospheric Research Lab. From 1949 to 1959, he was with RCA engaged in the development of advanced military systems using color television. Since 1959, Mr. Underhill has been a Senior Staff Member of Arthur D. Little, Inc., an industrial research company with headquarters in Cambridge, Massachusetts. There he has participated in and directed studies aimed at assessing the technical-economic constraints on CATV, pay television, and ETV, and has provided consulting services in management, marketing, engineering, company policy, and corporate assessment to many companies.

HOME TV VIA SATELLITE

By BRADFORD B. UNDERHILL / Arthur D. Little, Inc.

Can we use space satellites to broadcast TV directly to individual homes? What are the problems and can they be solved in the immediate future? Here are authoritative answers to these and other important questions.

Editor's Note: We recently attended a financial seminar presented by the National Community Television Association, Inc. in New York City. During the all-day session over a dozen papers were presented dealing mainly with the financial aspects of CATV. Included were papers by Milton J. Shapp, president of Jerrold Corp., on the history, size, and relationship of CATV to the broadcasting industry; by Willard E. Walbridge, representing the National Association of Broadcasters, on the broadcaster's viewpoint; by Frederick W. Ford, former chairman of the FCC and now president of NCTA, on industry relationship with FCC and Congress; by E. William Henry, chairman of FCC, on the FCC view of CATV; and others. Among the most interesting and important was the talk on satellite broadcasting by Bradford B. Underhill. A portion of Mr. Underhill's presentation dealt with the possible use of satellites in connection with a CATV system. Of more general interest, however, were his remarks on the feasibility of using satellites to broadcast TV programs directly to our homes. This is a subject of widespread and increasing interest today, especially in view of the successful use of Telstar, Syncom, Relay, and Early Bird communications satellites. Because of its importance to our readers, we have excerpted below a large portion of Mr. Underhill's remarks.

IN discussing the impact of space satellites on the future of world-wide television programming, we will consider the technical-economic feasibility of a satellite system that could, conceivably, transmit 8 to 12 channels of TV to individual homes. (Ideally, we would, of course, like to postulate over 100 channels which would allow a wide choice for the individual television viewer; but a discussion of 8 to 12 channels will, I believe, adequately demonstrate the overall situation.)

Clearly, if a television set coupled with a relatively simple, unobtrusive, and cheap antenna system at each home could, at any one time, pick up over 100 different TV programs ranging from comedy through education, news, serious plays, and do-it-yourself material, we would have reached a very advanced state of communications. Even the ability to *select* 8 to 12 different and interesting programs would provide a new dimension to television, particularly if the selection were on a national or even international basis.

Let's consider the practicality of the idea of using space satellites to broadcast TV directly to individual homes. Any communications system requires a source or transmitter and a receiver. In a satellite system, whether located on the ground or in the air, the satellite performs two functions; that is, it must receive signals from the primary transmitter or transmitters and then amplify and repeat selected signals to selected audiences.

Conceptually, a space satellite can distribute signals on a grand scale. Consider a high-altitude space satellite that hovers over essentially the same spot on earth 24 hours per day, 365 days per year. It could receive signals from anywhere on almost one-half of the world and repeat this to the same portion of the world. One such satellite could cover *all* of North America, South America, and much of Europe and Africa. Two more could cover 95% of the populated world. Compare this with the 35- to 40-mile television reception available today. The comparison is staggering.

Such a satellite, operating at an altitude of about 22,300 nautical miles, is called "synchronous" since it keeps pace with the earth's rotation. Another possibility imagines non-synchronous satellites operating at a much lower altitude—say, 300 miles—which move with respect to the transmitter and receiving stations. In order to keep each satellite in view of its neighbors and the ground, at least *ten* such satellites would be required. Each would have to be tracked by appropriate ground stations and each would have to transmit to the ground as well as to its neighbors. In addition, each receiving station would have to track the satellites as they move across the zenith and acquire the next one as it becomes visible. We do not believe that such a system will prove feasible for home use, but concede that COMSAT or some such organization might be able to develop a base for non-synchronous satellite global communications with heavy government support.

Assuming you will accept the loosely supported contentions as far as non-synchronous satellites are concerned, let us examine the case for synchronous satellites. Remember that this is a satellite that remains over essentially the same spot on earth and can receive signals from anywhere in its field of view and retransmit to that same wide area; roughly one-half of the world can be seen from such a satellite. A synchronous orbit is operationally desirable in order to avoid problems of pointing antennas toward the satellite and making contact with (acquiring) the satellite as it rises over the horizon.

The satellite must contain a source of electrical power. At the present time, photovoltaic cells which draw power from sunlight are the commonest source of satellite power. Conventional batteries are nearly useless for long-time activity. In the future, nuclear devices capable of generating a substantial amount of electric power for long periods of time may be generally available for communications satellites. Until nuclear power supplies are available, transmitted power from a satellite will be severely limited, for a solar-battery power supply weighs about one pound per watt of continuous available power.

The satellite platform will contain the receiving antenna and amplifier, modulator, a rebroadcasting transmitter, and a transmitting antenna. As these antennas must have high gain and correspondingly narrow beams, the attitude

Antenna Diameter

Freq. (MHz)	19-dB Gain (covering approx. a hemisphere)	29-dB Gain (covers 2500 × 4000 nautical-mile oval)	39-dB Gain (covers 800 × 1200 nautical-mile oval)
60	18.5 m (61 ft)	58.5 m (193 ft)	185 m (610 ft)
200	5.55 m (18.2 ft)	17.6 m (57.6 ft)	55.5 m (182 ft)
600	1.85 m (6.1 ft)	5.85 m (19.3 ft)	18.5 m (61 ft)

where: dB = 10 $\log_{10}$ P1/P2 or 2× power = 3 dB; 10× power = 10 dB; 100× power = 20 dB.

Table 1. Diameter of various high-gain transmitting antennas.

Table 2. Effective capture area of omnidirectional antenna.

Freq. (MHz)	Effective Area (sq meters)	Gain (dB) Relative to one sq meter
60	1.99	3
200	.179	-7.5
600	.0199	-17

control of the platform must be sufficiently precise to aim the antennas within appropriate tolerances. This problem is not insurmountable, but every sharpening of the attitude tolerances increases the complexity of the attitude sensor and control system and adds to the amount of energy which must be available for attitude control.

The receiving ground complex consists of receiving antennas and receivers, that is, an amplifier and demodulator to convert the signal back to the preferred usable form. With the satellite in a practically stationary orbit, a complex control system is not needed to aim the ground antenna.

Down-Link Power Computations

At first sight, the transmission properties of the link from the ground to the satellite look very much like those of the link from the satellite to the ground. The principal asymmetry is that in the up-link the transmitter is on the ground and the receiver is in orbit, whereas in the down-link the transmitter is in orbit and the receiver is on the ground. The state of our technology is such that we can install more powerful elements on the ground than we can in orbit. Practically speaking, this usually makes up-link performance easier to achieve than down-link performance, for a ground transmitter can be vastly more powerful than an orbiting transmitter, whereas a ground receiver can only be a little more sensitive than an orbiting receiver. Consequently, we shall examine the power budget for the down-link only.

Frequency Assumptions: We will confine our discussion primarily to the existing television broadcast frequency bands at 54 to 88, 174 to 216, and 470 to 890 MHz. For specific numerical examples, we chose frequencies of 60, 200, and 600 MHz as representative of these three bands. Still higher frequencies, *i.e.*, 2000-7000 MHz might be used but these would require expensive conversion equipment at each home.

Radiated Power Assumptions: Where there is dependence on solar power, it is likely that the maximum continuous radiated power will not exceed a few watts, perhaps 10 watts at most. When nuclear or other power supplies are available, the primary power limitation is removed and the significant limit will arise from constraints on dissipation and life-time in the power output stages of the transmitter. We believe 100 watts radiated power will represent a likely maximum for the next decade. Under extreme conditions, power of 1000 watts may be attained. However, even with ground-based equipment, current technology does not attempt to achieve long life-time and high reliability in electronic circuit elements operating at power levels of even one kilowatt; reliability relies on replacement. The ordinary techniques of enhancing reliability by overdesign and derating are ineffective where high power throughout is required. These suggested limits are consistent with the guidelines cited by G. M. Northrup in a paper prepared for the *Rand Corporation* in 1963. Accordingly, I shall assume a total radiated power from the satellite of 100 watts except where otherwise stated.

Satellite Transmitting Antenna Directivity: The effective radiated power from the satellites can be enhanced 80 times (19 dB) with a directional antenna whose beam just illuminates the near-hemisphere visible from the satellite. An antenna 10 times as large will illuminate, in the temperate zone, an oval about 2500 × 4000 nautical miles, and will have a gain of 800 (29 dB). An antenna 10 times larger yet will have a gain of 8000 (39 dB) and illuminate an oval about 800 × 1200 nautical miles. At the frequencies under consideration, however, these antennas are quite large, as shown in Table 1.

Although very large antennas have been considered, we have as yet no experience in the erection and operational use of antennas even as large as 60 feet, to say nothing of antennas 10 times this diameter. Furthermore, a 29-dB antenna has a beamwidth of about 6°, and a 39-dB antenna has a beam width of less than 2°. The pointing of such a sharp beam adds a burden to the attitude control system of the platform.

For the moment, let us assume the 19-dB antenna on the satellite and defer consideration of higher gain antennas until later.

Path Loss: Because of the way certain standards of television signal strength have been developed, comparisons are facilitated by computing signal strength at the earth's surface directly in terms of received power density per unit area for one channel. Let us assume that the 100 watts which is radiated through a 19-dB gain antenna is equally divided among 12 channels, each having a bandwidth of 6 MHz. The slant range from the satellite to the temperate zones is approximately 45,000 kilometers. On the ground the power density is: $PD = 2.6 \times 10^{-14}$ watt per square meter or 26/1000th of a micromicrowatt/meter^2.

Receiver Antenna Directivity: The effective capture area of an omnidirectional antenna is shown in Table 2 for the various frequencies under consideration. A half-wave dipole antenna has 1.6 times (2 dB) more directivity, provided it is appropriately aimed. Combinations of reflectors and multiple dipoles can give gains of several decibels, but more substantial gains require structures whose size is comparable to those shown in Table 1.

An antenna with more than a few dB gain is likely to be large and expensive. Such antennas will probably be ruled out in applications where one would be required for each home television user. For the sake of comparison, further

Table 3. Grades of television service and the FCC regulations governing them.

	Local Community Service		Grade A Service		Grade B Service	
Freq. (MHz)	Field Strength (μV/m)	Power Density (watts/m^2)	Field Strength (μV/m)	Power Density (watts/m^2)	Field Strength (μV/m)	Power Density (watts/m^2)
54-88	5,010	6.66×10^{-8}	2510	1.67×10^{-8}	224	1.33×10^{-10}
174-216	7,080	1.33×10^{-7}	3550	3.34×10^{-8}	631	1.06×10^{-9}
470-890	10,000	2.65×10^{-7}	5010	6.66×10^{-8}	1580	6.61×10^{-9}

From: "Television Engineering Handbook," Donald G. Fink, ed.; McGraw-Hill, N.Y. 1957, pp. 2-35.

computations are based on the use of a non-directional receiving antenna. This factor can easily be modified by assuming some other antenna gain figures.

Noise assumptions: We have two bases for estimating noise limitation. On the one hand, we can use the grades of television service from the FCC regulations, as quoted in Table 3.

For convenience, the power density in watts per square meter has been computed and exhibited alongside of the field strength. On the other hand, we can base signal-to-noise relationships on thermal noise and an assumption about the noise temperatures of the receiver and the associated environment. A set of such assumptions is shown in Table 4.

In order for the television receiver to function properly, the signal strength must exceed the noise by a substantial margin. The exact amount depends on the grade of service required and on the character of the noise. It will be assumed that a signal-to-noise ratio of 26 dB is required for satisfactory service and that 5 dB additional margin is required to allow for system degradation other than that arising in the down-link from the satellite. If the noise is white thermal noise, this will result in a high-quality black-and-white television picture but one that is not totally free from visible noise effects. The sensitivity of color television to noise interference is somewhat greater.

Resulting Margins: Table 5 compares the received signal strength, as computed above, with the FCC standards and with the performance of a low-noise receiver with a 1000°K effective noise temperature connected through a non-directional antenna. The resulting figures are expressed in decibels and are all negative, showing the deficit in dB between the signal as it would be received from the satellite and the desired grade of service indicated at the head of the column.

It is easy to see that the FCC Grade B Service is closely parallel in signal strength requirements to that required by a low-noise 1000°K receiver with an isotropic antenna. Those of you who have ever tried to operate a television receiver in an area with Grade B Service, so-called fringe-area reception, know that with off-the-shelf home television receivers, the performance is very unsatisfactory without a directional antenna.

In one way or another, the deficit of 33 to 70 dB must be made good. If a 1000-watt transmitter can be used aboard the satellite, 10 dB can be gained at once.

The transmitting antenna gain may possibly be increased 20 dB at 600 MHz and 10 dB at 200 MHz. At 60 MHz it is hard to see how this could be increased at all.

A receiving antenna six feet in diameter will have a gain of 20 dB at 600 MHz and 10 dB at 200 MHz. At 60 MHz it is fruitless to attempt antenna directivity because galactic noise at 60 MHz is greatly in excess of 1000°K noise assumed for the receiver. The highly directive antenna would focus on sources of high galactic noise periodically during the earth's rotation and nullify the desired improvement.

The receiver noise figure could be reduced somewhat provided a high-gain, low-side-lobe receiving antenna were used. This leads to a complex and expensive system, and would probably be useful only at the 600-MHz frequency; for even at 200 MHz, galactic noise is a significant source of interference. Let us assume a possible 5-dB improvement at 600 MHz. Table 6 shows the total improvement achievable by these means. It is clear that success is possible only at 600 MHz and that the margin is slim. Even this success is bought at the cost of a 1000-watt transmitter, a 60-ft diameter antenna on the satellite, a 6-ft diameter receiving antenna with low side lobes, and a receiving system operating at an effective noise temperature of 300°K on the ground. We believe that such a low-noise receiver antenna system would add a minimum of $200 to the homeowner's cost. Even if we are overly conservative, a home conversion cost of at least $6 billion is indicated to convert current TV households to satellite receivers. Without further analysis, it appears that this is hopelessly expensive for the ultimate users of such television signals.

Equivalent-Noise Assumptions	Noise Temperatures	Watts in a 6-MHz Band
Sky noise at 60 MHz (galactic noise, ctr. of galaxy)	10,000°K	8.28×10^{-13}
Sky noise at 200 MHz (galactic noise, ctr. of galaxy)	1,000°K	8.28×10^{-14}
Sky noise at 600 MHz (galactic noise, ctr. of galaxy)	100°K	8.28×10^{-15}
Typical vacuum-tube TV receiver	3,000°K	2.48×10^{-13}
Low-noise vacuum-tube receiver	1,000°K	8.28×10^{-14}
Typical uncooled parametric amp.	300°K	2.48×10^{-14}
Typical cooled parametric amp.	100°K	8.28×10^{-15}

Sources: "A Study of the Sources of Noise in Centimeter-Wave Antennas," D. C. Hogg, 1961. "Aids for the Gross Design of Satellite Communication Systems," G. M. Northrop, Rand Corporation.

Table 4. Equivalent-noise assumptions for various sources.

Freq. (MHz)	FCC "Local Community Service"	FCC Grade A Service	FCC Grade B Service	Isotropic Receiving Antenna*
60	-64 dB	-58 dB	-37 dB	-33 dB
200	-67 dB	-61 dB	-46 dB	-43.5 dB
600	-70 dB	-64 dB	-54 dB	-53 dB

Synchronous-altitude satellite radiating 100 watts divided equally among 12 channels through a 19-dB gain (full-earth coverage) antenna. (assumes 2.6×10^{-14} watt/m² available; Table 3 power required, and Table 2 antenna gain)
*19-dB transmitting antenna—26 dB S/N into 1000°K receiver, 5-dB margin.

Table 5. Deficit received power from a satellite system. Received power density in dB relative to various service grades.

Although the technical problem is made easier by going to frequencies above 2000 MHz, this would add the burden of conversion cost to the individual home owner and would still provide only marginal signal strength unless only a small portion of the earth were covered by the satellite.

The 9-dB deficit at 600 MHz could be made up by reducing the number of channels transmitted to only one or by increasing the power to 10,000 watts. The first is not attractive and the second is beyond our capability at this time.

Conclusions

There is no doubt that television transmission *via* satellite relay is technically feasible with a larger permanent ground antenna and receiver installation, but such installations cost many millions of dollars to build and hundreds of thousands of dollars per year to staff and maintain.

Such installations would allow economic world-wide transmission and reception of a single TV channel and several radio channels and would be attractive to the broadcasters. Retransmission to homes would be achieved by relaying the received information to the individual homes *via* cable or local transmitters. Certainly governments might find such a system valuable for (*Continued on page* 90)

Table 6. Additional system improvements that are available.

	Frequency in MHz		
	60	200	600
Transmitting Power	10 dB	10 dB	10 dB
Transmitting Antenna Gain	0 dB	10 dB	20 dB
Receiving Antenna Gain	0 dB	10 dB	20 dB
Receiver Noise Figure	0 dB	0 dB	5 dB
Total Improvement	10 dB	30 dB	55 dB
Required Grade B	37 dB	46 dB	54 dB
Required Grade A	58 dB	61 dB	64 dB
Local	64 dB	67 dB	70 dB
Grade A Deficit	48 dB	31 dB	9 dB

SONY HOME VIDEO RECORDER

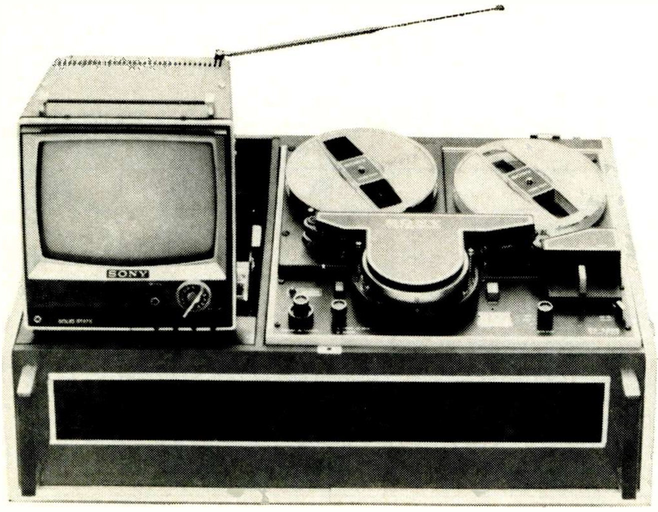
By C. H. FIELDS, Manager Technical Services
and SABUROU ONIKI, Staff Engineer
Sony Corp. of America

Technical description and design of a thousand-dollar, two-rotary-head machine for home and industrial uses.

Editor's Note: Just after the following article was received, we attended a demonstration of the first home video tape recorder that records and plays back color-TV pictures. The quality of the pictures played back on a conventional color-TV receiver was just about on a par with the original color pictures on the same receiver. The recorder, made by Sony, uses the same basic design as the black-and-white home video machine described below. It does, however, employ a somewhat higher tape speed (12 ips rather than 7½ ips), it uses four rotating heads rather than two, and it has additional circuitry for color-signal processing. The color home video tape recorder is expected to be available in the fall of 1967. Its price will be established after production starts. The company is also developing a color-TV camera for home use.

LAST September when *Sony Corporation of America* placed its home video tape recorder on the U.S. market for $995, it stirred up considerable interest. Prior to introducing its home machine, the company had been marketing a professional video tape recorder for medical, broadcast, sports, and transportation applications. The larger and more expensive professional equipment is still marketed for the fields for which it was designed, but the home unit is now attracting the bulk of the attention. This is because this new unit has so many uses with which the public can relate.

Over-all view of recorder (Model TCV-2010) and monitor.



An amateur golfer sees it as a means for improving his swing. The optometrist believes he can sell more framed glasses if he can show patients how they will look. The politician thinks of it in terms of improving his "image" if he has a chance to practice his speeches with the video tape recorder before going on the air. The entertainer sees it as a rehearsal aid to get ready for an actual performance or a tryout. While doting parents consider it in the light of a "living record" of their children's antics, their best parties, and family weddings, reunions, and holiday get-togethers.

To meet the needs of such diverse customers, the unit has been designed to be simple to use and capable of being operated without the need for mechanical adjustments. It works on regular house current and can be transported for use wherever a.c. current is available. It weighs 66 pounds and is approximately the size of a man's suitcase.

The *Sony* "Videocorder," with its tape deck, 9-inch monitor, and separately available camera ($350) is literally a home television studio. Its basic use in the home is with the camera for home movies or for recording favorite TV programs off-the-air. It is possible, using a timer switch, to record TV programs automatically for later viewing. Tapes can be erased and used again. A one-hour, ½" tape costs $39.95. (*A tape made on one unit, however, must be played back on the same type of unit.—Ed.*) Tape head life is 1000 hours and a replacement head costs in the neighborhood of $90.00.

Preliminary Relationships

Even though we are only going to discuss the recorder in terms of a block diagram, some preliminary relationships must be made clear first. Although the built-in 9-inch monitor may be switched on independently, no picture will be present on the screen since all video must go through the recording circuits of the tape deck. Operating the "power on/off" and the "record" push-buttons activates these circuits.

In this mode, the monitor is used to set up audio and video levels before the synchronous motor, which drives the tape transport and the rotary heads, is turned on.

When a satisfactory picture is obtained and the recording

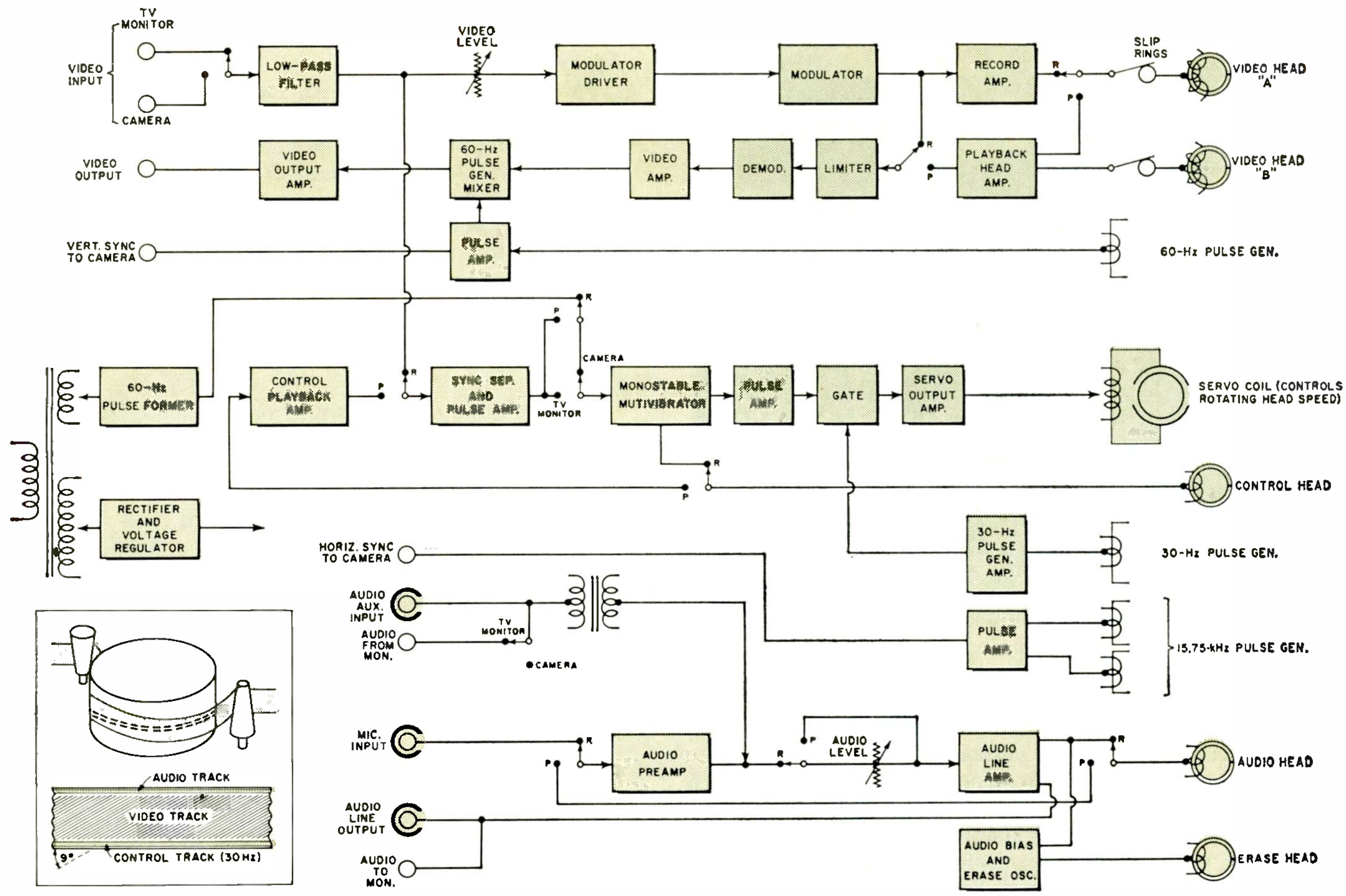


Fig. 1. Complete block diagram of the video tape recorder. Inset shows tape travel around drum and tracks on the half-inch tape.

levels are correct as read on the meter, the main motor is switched on, starting the tape drive and video head assembly. Within six seconds the servo system locks the video head assembly rotation to the synchronizing signal so that, during playback, the rotating video heads will track exactly over the recorded signal.

The tape path, as can be seen in the photo and in the Fig. 1 inset, is at an angle across the head drum. Thus, since the video heads are rotating in the horizontal plane, each head will follow a slanted track across the tape.

The inset diagram also shows the tracks laid down during recording. The top track is sound, recorded as in a normal audio tape recorder. The middle portion of the tape is video, each slanted line representing one field of the TV picture. The lower track is the control track which is recorded in the same manner as the audio track, but is a special signal controlling the angular position of the video heads to the tape so that during playback the heads will follow the slanted video track in an exact manner.

Video Recording Circuitry

Two inputs are provided to the tape deck (see Fig. 1). One is for use during camera recording while the other is for recording off-the-air TV programs. The operation is essentially the same for TV video or camera video, but the control-track signal is originated in a slightly different manner.

Video from either camera or off-the-air TV is applied to a low-pass filter which eliminates the higher frequencies, such as color burst and 4.5-MHz audio i.f. The full composite video signal is applied to both the "Video Level" control and the sync separator.

The "Video Level" control is an operator's control and provides a simple meter method of setting the optimum recording level. The modulator driver section provides pre-emphasis, clamping, and white clipping automatically, as well as impedance matching to the modulator. The composite video signal drives a modulator whose output is an FM signal. The output of this modulator is fed to the record amplifier and the limiter section. At the limiter section, any amplitude modulation is removed before the FM is demodulated. Output from the demodulator is again composite video.

The video amplifier, which also provides de-emphasis, feeds the mixer stage where a 60-Hz pulse is inserted just before the vertical blanking pulse of the composite video. The purpose of this short pulse will be explained later. The final stage provides output level and matching to the monitor.

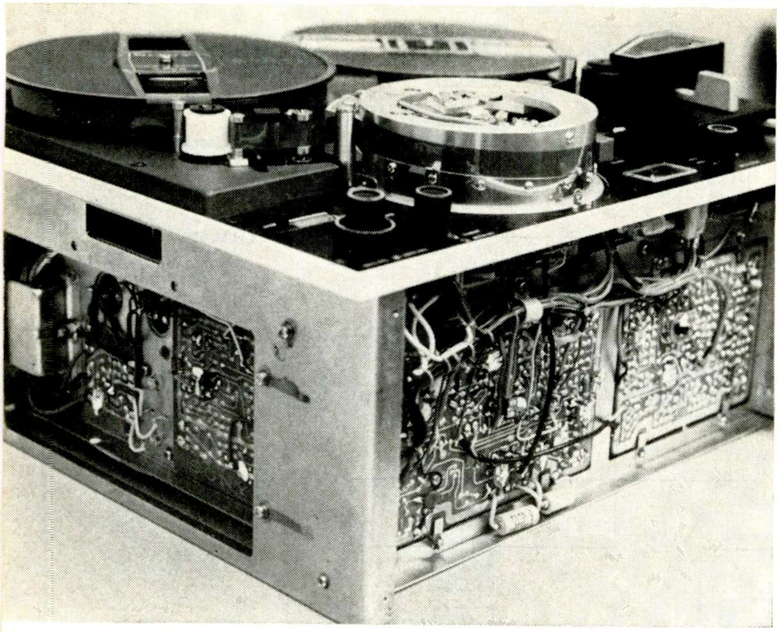
At this point we have followed the composite video path from the monitor (or camera) through the recording stages in the tape deck, and back to the monitor.

Returning to the modulator, the other path for the FM is through the record amplifier which provides FM recording current to the video head "A" only, through the brush and the slip-ring assembly. The record amplifier also compensates for the magnetic characteristic between tape and the "A" head.

Using only one head for recording takes advantage of the fact that there is very little difference in the video signal between one field and the next.

Therefore, in the "Videocorder," during "Record" (*R*), only every second field is recorded. One field is recorded durin each pass the "A" video head makes on the tape, the speed of rotation of the head assembly being 30 revolutions per second. In this way, during recording, the slanted video tracks may be "packed" closer together, in effect doubling the length of the tape. The effective writing speed is 433 inches per second.

The "B" head is so positioned that it must follow the "A" track exactly. Further, the "B" head starts at the beginning of the track just before the "A" head leaves the end of the same track. This overlap of the output of the two heads occurs during the vertical blanking period since the angular



Recorder is shown here with outer drum cover removed. Note particularly the tape travel path around tape drum.

displacement of the head assembly, in relation to the tape, is rigidly controlled by the vertical sync pulse.

By recording 30 fields per second and playing back each field twice per second, in succession, the total effect is as though both fields were originally recorded and 30 full frames are reproduced. The resolution is greater than 180 lines as observed on a standard EIA test-pattern chart.

The method of overlapping the video head outputs during the vertical blanking period is much simpler than the highly complex, expensive method of switching from head to head. However, this overlap produces spurious pulses which tend to mask the vertical sync pulse itself and produce an unstable vertical condition in the monitor picture, as the vertical oscillator in the monitor will be triggered at random by these pulses. To eliminate this condition and supply an unobscured, clear sync pulse for the monitor's vertical oscillator, a narrow 60-Hz pulse is inserted a few horizontal lines before vertical blanking. This 60-Hz pulse generator is a coil whose field is cut by two iron bars located precisely on the head drum (which is rotating at 30 rps). The resulting 60-Hz pulse is amplified by the pulse amplifier and mixed with the composite video. This provides the necessary clean pulse for vertical synchronization.

During playback, both heads provide signal to the playback amplifier which combines the two signals, ensuring that the level of each is uniform and correct to prevent saturation of the limiter stages.

The FM output of the limiters is demodulated, the composite video being amplified by the video amplifier section, and after the 60-Hz mixer stage, the video output section provides the gain and impedance matching to the monitor.

Servo Control Synchronization

The single hysteresis synchronous motor drives the capstan of the recorder at a constant speed, ensuring a tape speed of 7½ ips. The head assembly, however, is belt driven from the same motor by a special pulley at a rotation of slightly more than 30 revolutions/sec. The servo system and magnetic servo brake serve two functions: (*a*) By continuous, controlled braking, they guarantee that the head assembly rotates at exactly 30 rps; and (*b*) At the same time, they ensure that the "A" record head will assume the same instantaneous positions and thus follow the recorded track exactly. Without this close control, very poor and distorted video will occur on playback.

Synchronization for off-the-air TV is accomplished in a slightly different manner than for camera operation. Off-the-air TV will be considered first. During "Record," the vertical sync pulse is separated from the composite signal, integrated and amplified, before being coupled to the monostable multivibrator. The first of these 60-Hz pulses produces one usable pulse from the multivibrator. The second 60-Hz pulse is ignored by the multivibrator. The resultant pulse output after integration is applied to the gate circuit.

A 30-Hz reference pulse is generated by the pulse generator, is amplified, and is then used to "open" the gate. This pulse generator, like the 60-Hz generator, produces one pulse each time its field is cut by an iron bar on the rotating head drum.

The amplitude of the output from the gate, after integration and wave-shaping, is proportional to the difference in phase between the 30-Hz pulse generator output and the leading edge of a 30-cycle pulse generated by the extremely stable vertical sync pulses from the TV station.

The natural rate of rotation of the video head assembly is slightly higher than 30 rps. This would produce more than 30 Hz from the pulse generator. Since this pulse would, in effect, arrive too early in relation to the leading edge of the pulse from the monostable multivibrator, a longer, higher output would result. After integration, shaping, and amplification by the servo output amplifier, this waveform produces sufficient braking to reduce the speed of the head assembly to exactly 30 rps.

The physical position of all components is such that the two video heads must be held to extremely close limits in order to always retrace video information that had been previously recorded.

A second output of the monostable multivator stage is recorded by the control head on the tape. During playback, this pulse is picked up by the control head and, after amplification by the control playback amplifier, is fed to the sync separator/pulse amplifier. Here, after integration, it serves to trigger the monostable multivibrator which, as before, will produce braking by the servo coil. Since the recorded signal was produced by the off-the-air TV vertical sync pulse through this same path, the resultant amount of braking will ensure correct head rotation speed and position.

When the associated camera is used, a reasonably stable 60-Hz pulse is required to take the place (and provide the same function) as the vertical sync pulse. The 60-Hz a.c. provided by the electric utilities is held to close enough tolerance in the U.S. to suffice. A 6.3-volt winding on the power transformers supplies this signal to the 60-Hz pulse former which, after clipping, shaping, and forming is used during camera operation to trigger the monostable multivibrator. From this point to the servo coil the same sequence of events occurs as during TV operation.

To synchronize the camera accurately, trigger pulses generated in the tape deck are used. The camera vertical oscillator is locked by the 60-Hz pulse generator already discussed. The camera's horizontal oscillator is triggered, at 15 kHz, by pulses produced by two coils in close proximity to a wheel having 525 serrations in its circumference. As each serration passes through the fields of these coils a pulse is produced. Since the serrated wheel is mounted on the rotating head drum shaft, and revolves at 30 revolutions per second, each coil produces 30 × 525 or 15,750 pulses per second. The output level of the coils is balanced and then amplified by the pulse amplifier before being fed to the camera's horizontal oscillator.

Recording cannot be accomplished from standard TV receivers. The built-in monitor must be used for off-the-air recording. Playback may be accomplished through this monitor or through standard TV receivers whose video, audio, and horizontal a.f.c. circuits have been modified by means of a special video adapter to be marketed by *Sony*. ▲

Chroma Demodulation in Color Sets: RCA

By WALTER H. BUCHSBAUM

First of a series of articles covering modern color-TV theory. This portion includes details on the bandpass amplifier, the chroma demodulator, and matrixing used in the latest RCA sets.

MANY portions of a color-TV receiver perform the same functions as in a black-and-white set, but three groups of circuits—the chroma demodulator, the color sync, and convergence—are unique to color sets. The chroma demodulator circuits are often considered the most complex since they transform the chroma signal into the red, green, and blue information that creates the color picture on the CRT screen. To perform this function, the demodulators must receive the correct phase of color sync signal controlled by the 8-cycle burst transmitted immediately following the horizontal sync pulse. The color video signals are the product of the demodulator section and the color sync section, but the convergence section is needed to operate the color picture tube. This latter section determines CRT convergence not only for color but also for black-and-white transmissions.

This article covers the chroma demodulator and matrixing section of the new line of *RCA* color sets. The color sync and convergence sections will be covered in future articles.

Basic Operation

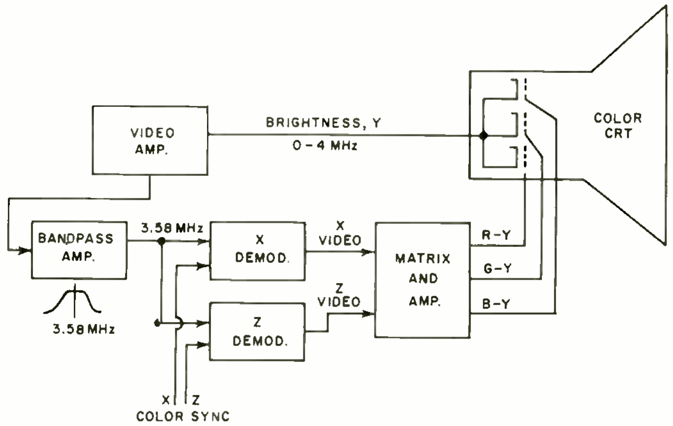
The entire process of converting the subcarrier information into the red, green, and blue video signals consists of three distinct steps. First the subcarrier is amplified and limited in its frequency response. Then phase and amplitude demodulation takes place and, finally, the demodulated video signals are mixed in the proper amplitudes and polarities to produce the three color video signals. This sequence and the parameters associated with each step are illustrated in Fig. 1. From the 0- to 4-MHz over-all video signal, the 3.58-MHz subcarrier and its sidebands are selected by the chroma bandpass amplifier. The signal obtained from its output is a 3.58-MHz carrier which varies both in phase and amplitude, in accordance with the chroma information generated at the transmitter.

To detect the chroma component, it must be remembered that any color is specified by three quantities: brightness, hue, and saturation. The brightness component is the video, or *Y*, signal which has full 4-MHz bandwidth and which furnishes the monochrome picture. Only hue and saturation are encoded on the subcarrier. If hue is considered as phase angle and saturation as amplitude, any resultant vector can be composed of different amplitudes of two reference vectors with fixed phase angles. In the *RCA* models, these are called the *X* and *Z* axes, with their phase angles shown in Fig. 2A. In the demodulator, the color subcarrier is then compared against these two phase angles, and the resultant amplitudes constitute the *X* and *Z* video signals. These two signals can be matrixed into the red, green, and blue color-difference signals as illustrated for the $R-Y$ axis shown in Fig. 2B. They are called color-difference signals because they lack the *Y*, or brightness signal component, which is transmitted as a normal monochrome signal.

Bandpass Amplifier

In the *RCA* Model CTC19, two stages of video amplification are used for the *Y* signal. The first stage, as shown in Fig. 3, is a cathode-follower that drives the *Y* delay line. A separate pentode is used to amplify the color subcarrier. This stage contains a peaking coil (*L1*) and a small-valued coupling capacitor (*C3*) to emphasize the higher video frequencies but is not tuned specifically to the color subcarrier.

Fig. 1. Block diagram of a typical chroma demodulator section.



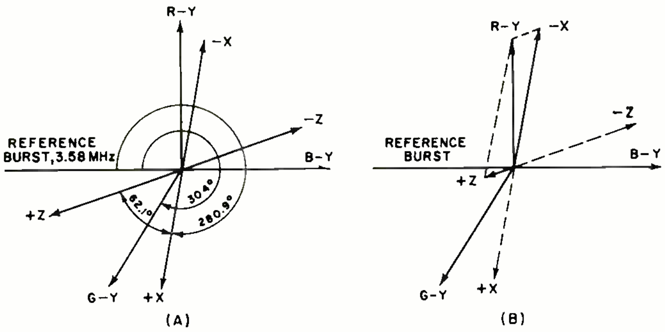


Fig. 2. (A) Color axes phase relation. (B) How R—Y is formed.

At the grid of the bandpass amplifier, a tapped coil (*L2*) resonates with the grid capacitance at 3.58 MHz, while the plate circuit uses a double-tuned transformer (*T1*), with *R8* loading the secondary to assure broad bandpass. The over-all response curve of the bandpass amplifier stage, as shown in Fig. 4A, is made up of the frequency response of the tapped grid coil (Fig. 4C) and the double-tuned output transformer response of Fig. 4B. Note that the bandwidth is 0.5 MHz on either side of the 3.58-MHz subcarrier and that a much greater tolerance is permitted on the high-frequency side of the response curve. The information contained in the upper and lower sidebands of the subcarrier is identical and will appear redundant to the demodulator.

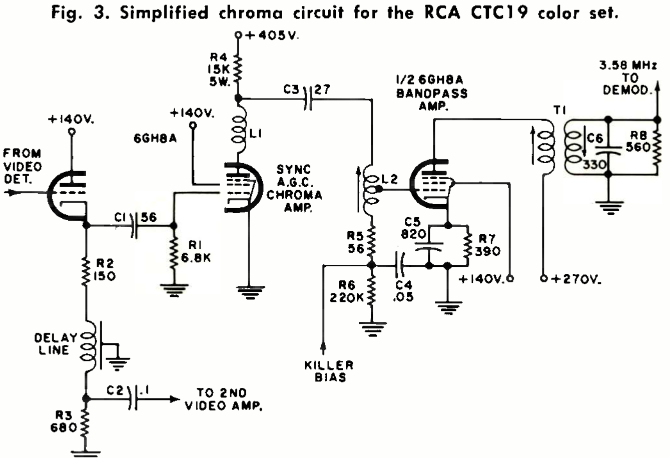
The chroma amplifier must provide enough gain to drive the two demodulators. Since in this model the demodulator screen grids receive the chroma signal, sufficient power must be developed in the chroma bandpass stage. The circuit of Fig. 3 will provide 25 volts peak-to-peak across *R8*, or about 1.1 watts peak when the grid signal is 9 volts peak-to-peak.

In the *RCA* CTC16 and CTC17 models, three stages of video (*Y* signal) amplification are used, with the second stage driving the delay line. Here, the color subcarrier is obtained at the plate of the first video amplifier and then amplified in a circuit which is almost identical to the one shown in Fig. 3 and which results in the same response curve. In all *RCA* models, the grid of the bandpass amplifier gets a d.c. bias from the plate of the color-killer stage. When a monochrome signal is received, there will be no color sync burst on the horizontal interval blanking pulse, and the color killer generates a high bias which cuts off the bandpass amplifier thus removing the color signal.

Chroma Demodulators

From the chroma bandpass transformer, the signal goes to the color control potentiometer. This control determines the amplitude of the color subcarrier which will be applied to the two demodulators and therefore controls the intensity of the colors on the CRT screen. As illustrated in Fig. 5, both demodulator tubes receive the chroma signal on their screen

Fig. 3. Simplified chroma circuit for the RCA CTC19 color set.



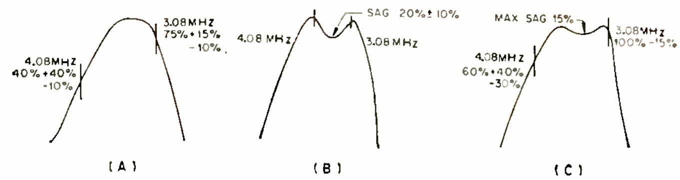


Fig. 4. (A) Over-all chroma bandpass. (B) Transformer response. (C) Grid coil response. These are for the circuit of Fig. 3.

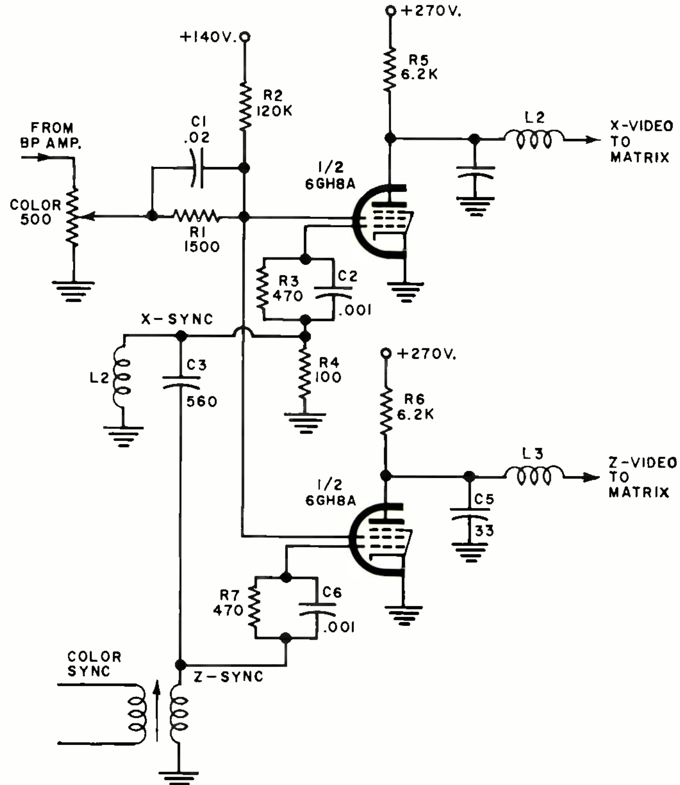


Fig. 5. Simplified chroma demodulators as used in RCA sets.

grids. The d.c. level at both screen grids is partly determined by the setting of the color control potentiometer, since it forms a voltage divider with resistors *R1* and *R2*. Variation of the potentiometer setting can change the screen grid voltage from about 1.6 to 1.2 volts. At any of these values, the screen voltage is so low that it permits very little current to flow through the tube. Both demodulators operate in exactly the same manner; the only difference between them is the phase of their color sync signals.

To understand the operation of the pentode demodulator, all of the voltages on the tube must be considered. The plate goes to +270 volts through *R5* (*R6*) and, with normal screen grid voltage, the tube would act as a high-gain video amplifier. During each positive portion of the applied color sync, the tube is turned on and, depending on the level of the signal at the screen grid at that instant, more or less current will flow from cathode to plate. In other words, the color subcarrier is sampled during the positive peaks of color sync, and the amplitude of the output signal will then depend on the amplitude and phase of the chroma subcarrier when compared with the amplitude and phase of the signal applied to the control grid. The true effect of the phase variation becomes apparent when a detailed analysis of the demodulating process is made and both the *X* and *Z* color sync phases are considered.

Fig. 6 (left) illustrates a typical portion of a 3.58-MHz phase- and amplitude-modulated subcarrier (A). Below this, the *X* color sync signal with the cut-off bias of the tube indicated by a horizontal line is shown (B). If the tube can conduct only during the short intervals when the color sync signal goes above the cut-off bias, the resultant plate voltage

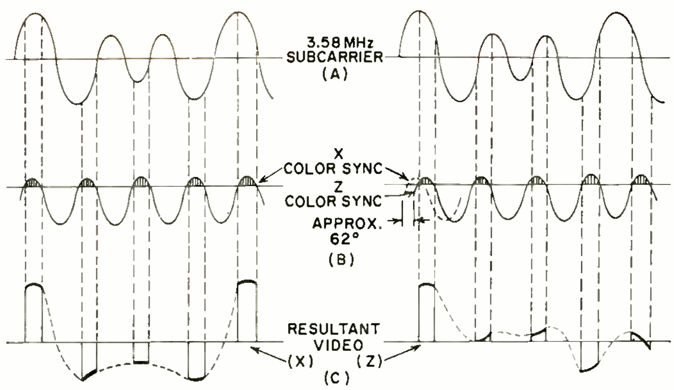


Fig. 6. (A) Modulated color subcarrier. (B) 3.58-MHz oscillator signal. (C) Resultant video for X channel (left) and Z (right).

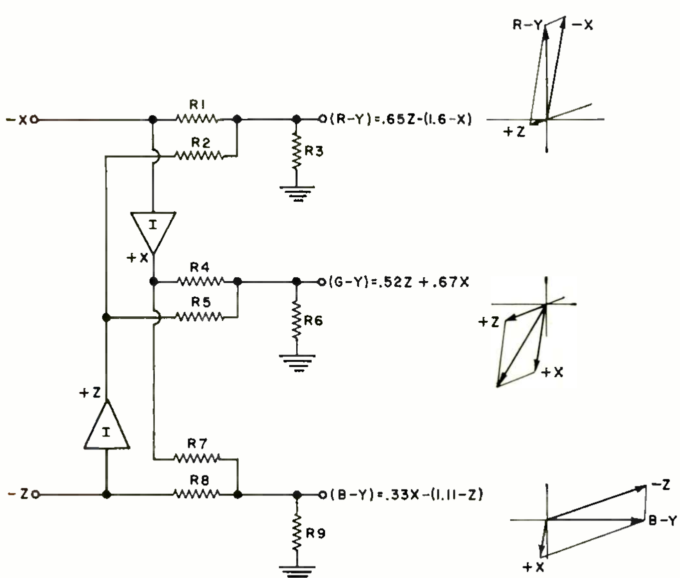


Fig. 7. Principle of matrixing X and Z into R — Y, G — Y, and B — Y.

will be very much like the short pulses shown at (C). The output of the demodulator consists of a series of short pulses, occurring at the 3.58-MHz rate, and varying in amplitude according to the phase and amplitude relationship of the subcarrier to the color sync. The video signal is obtained by integrating these pulses, using a capacitor, to produce a waveform as indicated by the dotted lines connecting the individual pulses of (C). To illustrate the effect of the approximate 62° phase delay between the *X* and Z color sync signals, Fig. 6 (right) shows operation of the Z signal, the only difference being the relative phase between the subcarrier and the color sync signal. Note that the two resultant video signals are different from each other. At the output of the *X* and Z demodulators (Fig. 5), a capacitor and peaking coil provide the integration and also act as a filter for the 3.58-MHz color subcarrier. As a result, the output of the *X* and Z demodulators will be a completely integrated, smooth video signal whose highest frequency is about 500 kHz.

In the *RCA* CTC16 and CTC17 series models, the demodulators are 6HZ6 pentodes with the screen grids operated at d.c. Here, the color subcarrier is applied to the control grids and the color synchronizing signal is applied to the respective suppressor grids. The 6HZ6 has a characteristic permitting the suppressor grid to cut the tube off. Because the color subcarrier is applied to the control grid, less power is required as compared with the signals on the screen grid of the CTC19 model. In all other respects, the *X* and Z demodulators in the CTC16 and 17 series are identical to those in the CTC19. After demodulation, the signals are then matrixed to form the color difference signals.

The red, green, and blue color-difference signals can be obtained from the *X* and Z video by adding the relative amplitudes and polarities, and Fig. 2B illustrates how the $-X$ and $+Z$ vectors could be used to produce the $R-Y$ signal.

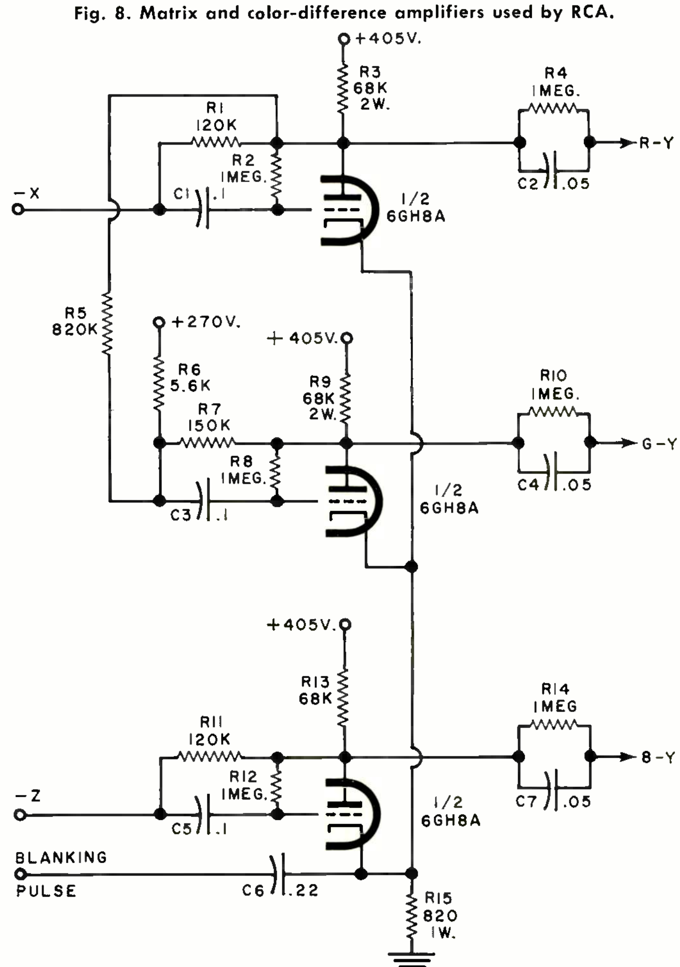
Matrixing

The principles of the complete matrixing process are illustrated in Fig. 7 where it is assumed that the $-X$ and $-Z$ signals, rather than the $+X$ and $+Z$, are developed by the demodulators because this simplifies the explanation. If the *X* and Z signals were positive, the connections of the inverters in the circuit of Fig. 7 would change, but the relative amplitudes would remain the same.

In the matrixing process, only signal polarities and amplitudes are used. As shown in Fig. 7, both *X* and Z signals are combined in a matrix to produce the three color-difference signals. In this *RCA* set, for example, the angle between $R-Y$ and the $-X$ vector is 10.9° and the angle between $R-Y$ and the $+Z$ vector is 107°. Based on these angles, trigonometry allows us to calculate the lengths of $-X$ and $+Z$ to produce an $R-Y$ of unity length. As shown in Fig. 7, this turns out to be 1.6 for $-X$ and .65 for $+Z$.

The $-X$ signal is applied through *R*1 and the $+Z$ signal is obtained from an inverter and applied through *R*2 across *R*3. With the correct resistor relationship, the resultant signal can be made equal to $R-Y$. The $G-Y$ and $B-Y$ signals are constituted of their respective components of *X* and Z in the same manner. Note that both polarities of *X* and Z are required to produce the three color-difference signals. Fig. 7 shows the relative amplitudes of *X* and Z required to produce the color-difference signals with unity amplitude. In analyzing the actual receiver circuitry, however, it must be remembered that unity amplitude of all three colors rarely occurs. White is shown on the screen when 0.30 red, 0.59 green, and 0.11 blue components (*Continued on page* 67)

Fig. 8. Matrix and color-difference amplifiers used by RCA.



How to select R. F. Chokes

By JOSEPH TARTAS

There is more to an r.f. choke than some wire wound about a form. When all its characteristics are known, it can prove useful as a tuned circuit, transformer, low-or high-pass filter, as well as an r.f. isolator.

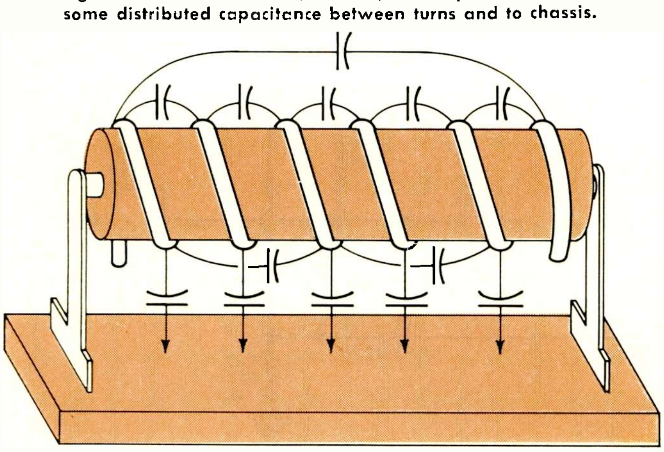
NOT so many years ago, the selection of an r.f. choke was not a difficult problem. You simply asked for a Z-50, if you were working in the 50-MHz area, or a Z-14 if your circuitry was in the 10- to 15-MHz range. Chances were, you didn't know anything about the choke itself, other than taking the manufacturer's word that it was designed to work in that range.

For very-low-frequency work, the selection of a choke usually depended more on the inductive reactance and hence was usually some arbitrarily selected value of high inductance. If you were really designing, you might make a lot of calculations and measurements, throw in a few rules of thumb, and come up with the right value.

Today, the picture has changed considerably and instead of two or three makes of chokes and a dozen or so values to select from, there are hundreds of sizes and shapes as well as specific characteristics to meet extreme temperature, moisture, or other environmental requirements. In a single manufacturer's line, there are several physical sizes designed to fit requirements of current-carrying capabilities and space limitations; and in cases of extremely small volume, there are non-insulated chokes to reduce the physical size but retain the same electrical characteristics.

The most important improvement in the RFC field in the past few years is the information made available to the user through manufacturers' literature. This information includes inductance; minimum "Q" (although often misleading—this will be discussed farther on); approximate resonant frequency, perhaps the most important item; the approximate distributed capacitance; the minimum parallel resistance at two widely separated frequencies; the maximum d.c. resistance; the maximum current rating; and in the case of one manufacturer, incremental current rating. Because of extreme environmental requirements in military and industrial equipment these days, many chokes are also rated for maximum temperatures ranging from 85° to 500°C and power dissipations that depend upon body sizes, covering materials and core materials.

Fig. 1. Besides inductance, an RFC, like any other coil has some distributed capacitcnce between turns and to chassis.



In spite of all this information, it often requires a bit of reading between the lines before you can make a sensible selection of the correct RFC to use in your particular circuit. Before you can do this, however, you must have a thorough understanding of the various characteristics and circuit requirements that go into such a selection.

Why a Choke Is Used

Basically, an r.f. choke is nothing more than an inductance that, because of its own distributed capacitance, forms a parallel-resonant circuit. This distributed capacitance (Fig. 1) is a multiplicity of small capacitances existing between adjacent turns and from any one turn to all the others, as well as to a shield if one is used, and to a ground if one exists

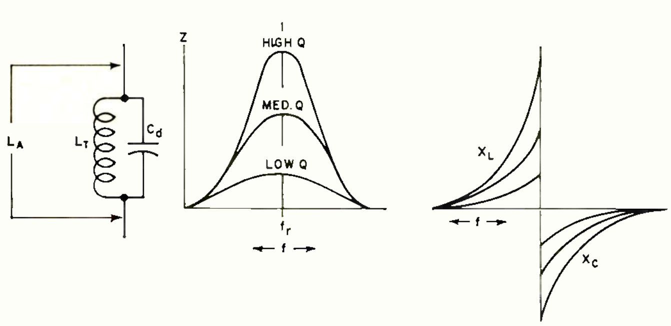


Fig. 2. (A) How an RFC looks electrically. (B) and (C) show "Q" and reactance, respectively, for different values of "Q."

in the vicinity of the choke when it is installed in the equipment. For the moment, consider the self-capacitance, or distributed capacitance itself (without the choke-to-ground capacitance), as being in parallel with the pure inductance of the coil and having a resistance equivalent to the resistive component of the choke. A choke would then appear schematically as in Fig. 2A, and its impedance and reactance as in Figs. 2B and 2C, respectively.

As in all parallel-resonant circuits, the maximum impedance at resonance will depend upon the "Q" and this, in turn, will be the deciding factor as to how effective the choke will be at its self-resonant frequency and over how wide a frequency range it will still be effective. The impedance depends upon the amount of self-capacitance that exists in the choke and the equivalent parallel resistance. A good approximation of the impedance of a parallel-resonant circuit is $Z_r = L/CR$ as long as the circuit "Q" is at least 10. The value of R is normally the sum of the series resistances of the inductance and capacitance, but in a choke the resistance involved in the distributed capacitance is practically non-existent. This, then, boils down to the inductance, the distributed capacitance, and the resistance of the winding (d.c.+r.f. resistance as frequency goes higher) as affecting the over-all performance of the choke; that is, the resonant impedance, the self-resonant frequency, the "Q" and hence the bandwidth of the choke, and its effectiveness on the r.f. voltages it is being used to suppress. Thus, it is obvious that the value of inductance of a choke is not as important as the self-resonant frequency and impedance, although the inductance does have some bearing on these factors.

Chokes come in many forms, the particular type depending upon the frequency involved, the inductance necessary to achieve it, and the distributed capacitance that results from the particular form factor and winding method. Many are simple single-layer solenoids with or without powdered-iron cores; others are multi-layer coils of various configurations; still others are single or multiple honeycomb windings with one or more sections combined in series.

A single-layer solenoid has the lowest distributed capacitance, and this capacitance is proportional to the diameter of the winding and to a smaller degree is affected by the length and number of turns and, where only a few turns are involved, the spacing between turns. For a single-layer, close-wound choke, the distributed capacitance is approximated by $C_d = .75$ diameter (in inches), with C in pF.

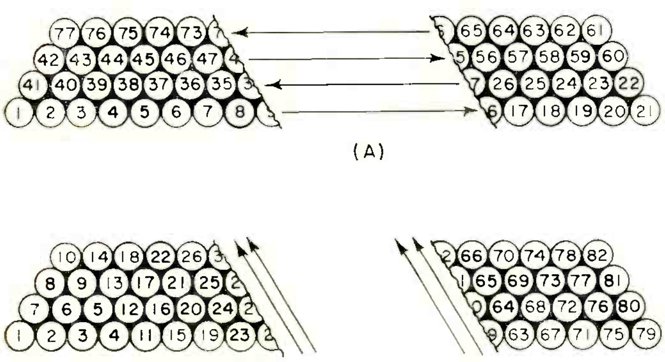


Fig. 3. Two different methods of winding multi-turn coils. Note winding arrangement difference between (A) and (B).

In a multi-layer coil (Fig. 3A), the capacitance is considerably greater, not only because of the greater number of turns but also because of the relative capacitances between layers and nearby turns. If the layers are wound so that the difference of potential between any two adjacent turns is small, then the capacitance is small; if the layers are wound in such a way as to have adjacent turns non-parallel to each other, as in the honeycomb or universal winding, the capacitance is at a minimum between those adjacent turns. The total distributed capacitance may be further reduced by the use of powdered-iron or ferrite cores which reduce the number of turns of wire necessary to obtain the desired inductance value. However, other problems enter when cores are used, since the core losses, the capacitance effects due to the dielectric material used in making the cores, and the useful temperature range and effective permeability of the core which affect the "Q" must be considered, as well as a factor that is often ignored in r.f. chokes, the temperature coefficient of the core, which also affects the temperature coefficient of the choke.

In multi-section chokes, the individual sections may be alike or may be designed so that the over-all choke appears as a broadband filter. In most cases, the choke is not like a single resonant circuit but appears electrically as a multi-element bandpass filter.

When a large inductance is required and the use of a single-layer coil is prohibitive because of its size, the multi-layer coil becomes necessary. This, in turn, means a larger distributed capacitance which is no longer directly related to the diameter or coil size. One method of reducing capacitance is to wind the coil in such a way that the high-numbered turns do not lie next to low-numbered turns (the condition for greatest capacitance). Early attempts to reduce capacitance by means of "bank-winding" (Fig. 3B) resulted in expensive chokes, since this method required great skill by the winder and it could not be done by machine. The coil could not be held to the production tolerances then required (and completely unusable with today's close-tolerance requirements), and when large inductances were needed, the coil was so large physically as to be almost impractical.

The development of the universal coil winder provided the designer with a new and extremely useful tool that allowed him to repeatedly produce a mechanically stable, relatively low capacitance coil with a fairly large inductance. This type of winding, while not having the lowest attainable capacitance, was better than a "happy medium" between the excessive capacitance of the layer-wound and the great expense of the bank-wound coil.

The "universal" layer-wound coil, more commonly known as "pie-wound" because of its resemblance to a pie, is a compromise between the bank-wound coil of Fig. 3B and the slot-wound coil of Fig. 4A.

The slot-wound coil has a distributed capacitance equal to a two-plate capacitor, each plate consisting of rings the width of the slot with one plate having the inner coil diameter A (see Fig. 4B) and the other plate the outer diameter B. Since a two-plate capacitor of two greatly different areas depends to a large extent on the area of the smaller plate, the smaller the diameter of the inside ring (or the winding form in this case) the smaller the distributed capacitance, and conversely, the greater the inductance the pie will have for a given width and outer diameter.

The universal-wound pie of Fig. 4C is simply a free-standing, self-supporting, slot-wound coil with a winding similar to the bank-wound coil, although restricted because of the narrow cross-section of the slot.

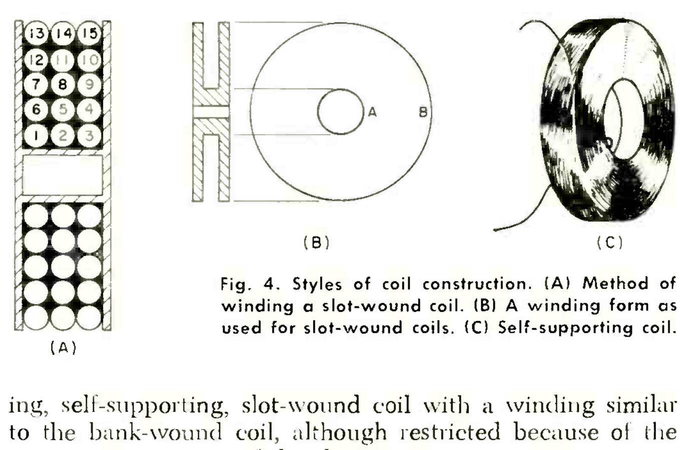


Fig. 4. Styles of coil construction. (A) Method of winding a slot-wound coil. (B) A winding form as used for slot-wound coils. (C) Self-supporting coil.

As the art progressed, powdered-iron cores were developed, and their use as forms or cores for universal-wound r.f. chokes allowed a great reduction in over-all size.

Like all new materials, powdered iron had its own limitations. If the permeability (μ, the ratio of inductance with the core, to the inductance without the core) was low, and the losses resulting from the insertion of the core in the coil (eddy losses) were kept to a minimum (resulting in a reasonably high "Q"), the size of the coil was not reduced greatly. In-

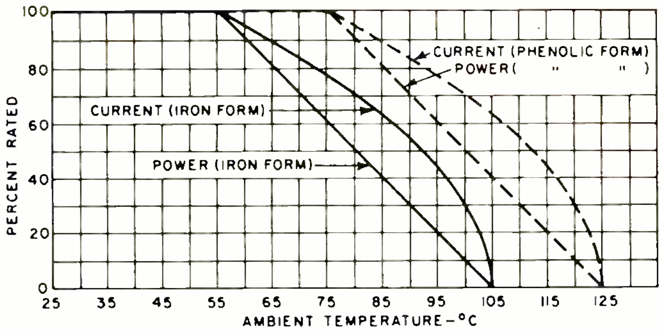


Fig. 5. Derating curve for one type of miniature r.f. choke.

creasing the μ of the core material reduced the choke size, but often it was found that the "Q" suffered greatly due to core losses so that the series impedance (QX) was inadequate to warrant the use of a costly and bulky component.

Eventually, new ferrite materials (ceramic materials with magnetic qualities) were developed which allowed for great reduction in the size of an r.f. choke, but as environmental temperature specifications for equipment were raised above the usual 85°C, the temperature capabilities of the ferrites fell apart. Either the temperature coefficient was poor, causing excessive change in effective inductance with change in environmental temperature, or the permeability decreased so rapidly above 85°C that the resulting inductance became too low to be effective long before the maximum temperature requirements were met.

This led to further improvements in the capabilities of ferrite core materials, and we now have extremely large inductances in very tiny packages with excellent temperature and mechanical stability, and because of the extremely high permeability of the cores, the distributed capacitance or "self-capacitance" of the choke remains quite low.

Examples of this size reduction are a miniature 1000-μH choke with a molded phenolic form having a distributed capacitance of 5 to 10 pF for several makes, and a ferrite-bodied choke with the same effective inductance yet having less than 1-pF capacitance.

Chokes having an iron core, for the same inductance, run somewhere in between, with a maximum capacitance of 7 pF.

In large chokes using non-miniature techniques, the capacitance is usually not given, and often the self-resonant frequency is ignored as well. Because these chokes are usually wound with larger wire to accommodate high currents, the capacitance of these chokes would be even higher than that of the miniature types.

The current rating of a choke will often depend upon the ambient temperature and will have to be derated. Fig. 5 shows a curve for derating one type of miniature choke. If the current rating is given at the maximum temperature to be encountered, then only the *incremental current* is of interest. This is the current necessary to reduce the effective choke inductance by 5% due to the magnetization of the iron core that effectively lowers the permeability and hence the inductance.

Chokes are normally used to prevent coupling of r.f. power (microwatts or megawatts) from one circuit to another in a piece of equipment. Any wires that lead from stage to stage, circuit to circuit, or from one sub-unit to another are potential conductors of undesired r.f.

In r.f. circuitry in particular, there is usually a series of cascaded amplifier or multiplier stages, and more often than not, an oscillator or two. Furthermore, mixers, detectors, and other associated circuits are commonly involved in such circuitry, and each is a source or terminus for leads that might conduct unwanted r.f. These leads can be any or all of the following: "B+," "B−," a.g.c., filament leads, fixed bias leads, leads to panel controls, and video or audio input and output.

Carefully selected, the proper choke can be an r.f. isolator; a shunt trap; a tuned circuit either at its self-resonant frequency or, by means of additional shunt capacitance, at some lower frequency; or can be combined with other components to make a low-pass, high-pass, or bandpass filter.

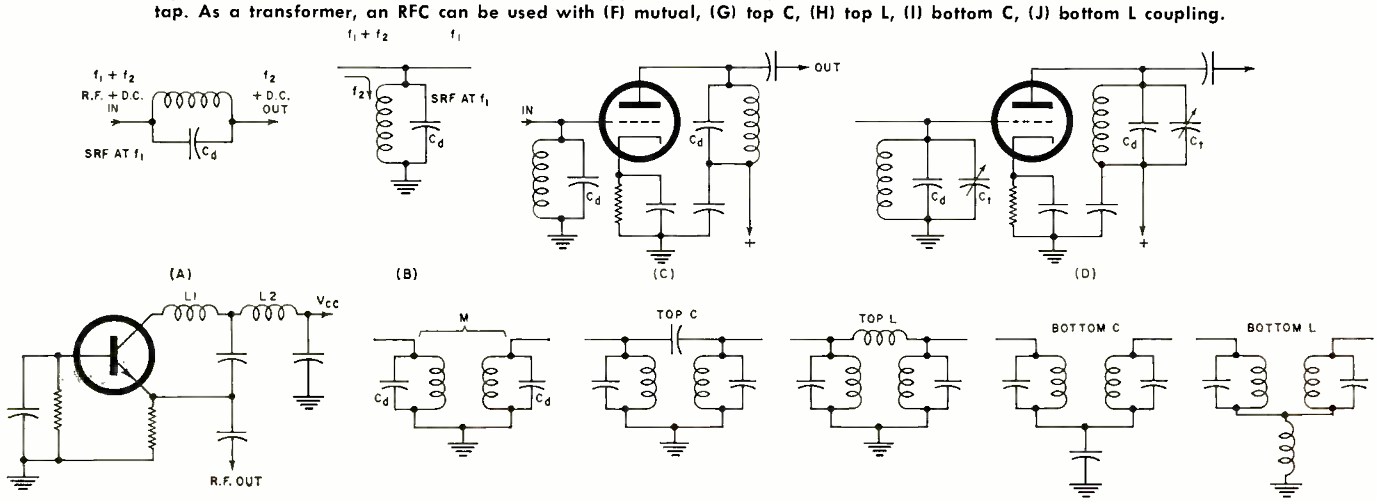
A recently introduced innovation is a series-resonant trap that is in appearance an r.f. choke. Utilizing the capacitance between turns as a series-coupling element, it can be made in a wide range of series self-resonant frequencies. Like the parallel-resonant choke, the series trap will probably find applications that formerly required an external capacitor in conjunction with an RFC to make a series-resonant trap.

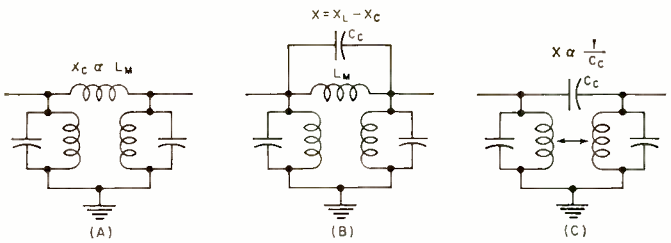
How to Use Chokes

Because a choke is composed largely of distributed inductance and capacitance rather than lumped inductance and capacitance, it appears electrically as a transmission line rather than as a tuned circuit. Depending upon the values of these constants and the terminating impedance of this transmission line, a choke can act as an impedance varying from extremely high to almost a perfect short.

At the fundamental (self-resonant) frequency and at all odd multiples of this frequency, a choke appears as a parallel-resonant circuit. At even multiples, the same choke acts as a series-resonant circuit with the lowest impedance limited only by the series-resonant resistance, or essentially the resistance of the coil itself. This phenomenon occurs because a choke does act as a transmission line and *is not terminated in its characteristic impedance.* If it were so terminated, a choke would be little more than a straight conductor or lossless transmission line for the r.f. currents.

Fig. 6. Various uses for r.f. chokes. (A) R.f. suppressor. (B), (C), (D) Used as a tank coil. (E) Tuned circuit with tap. As a transformer, an RFC can be used with (F) mutual, (G) top C, (H) top L, (I) bottom C, (J) bottom L coupling.





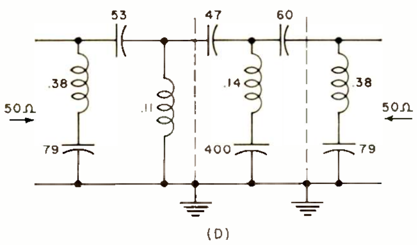


Fig. 7. (A) & (B) Coupling through a capacitor may reduce effective coupling as one RFC may tune out other. (C) Coil separation produces controllable coupling. (D) How RFC's are used in a typical high-pass filter unit.

Because of the distributed elements, a choke may be thought of as a series circuit composed of a number of elements, each element consisting of several small inductances and capacitances in parallel; as two parallel branches, with one leg a series of small coils and the other leg a series of small capacitors; or even as a combination of the two, which would make it the equivalent of multi-element filter circuits. Hence, at any given frequency, a choke can appear as almost anything from a high parallel-resonant impedance to a very low series-resonant impedance.

It is customary, however, to select a choke having its highest parallel-resonant impedance when it is to be used as an r.f. suppression element in a supply line (in series with a "B+" line, for example), as shown in Fig. 6A. If a choke is selected having the same self-resonant frequency (SRF) as the frequency it is desired to suppress, then the choke must have the *highest series impedance* at that frequency. And because a choke is a completely self-contained high-impedance element, its SRF is not affected by external elements connected from either end to ground, and further attenuation is achieved by bypassing either or both ends of the choke. It is, however, affected by any parallel elements, and hence its SRF, "Q," or parallel-resonant impedance can be lowered.

Because it can be altered, such a choke may be utilized as a tank coil and tuned by a fixed or variable capacitor connected across the choke (Figs. 6B, 6C, and 6D) and have its loaded "Q" adjusted by adding a parallel resistor (or tube or transistor circuit). Two chokes in series, with the combination shunted by a capacitor, provides a tuned circuit with a tap (or an autotransformer), as shown in Fig. 6E. The tap can be adjusted by the proper selection of the inductance ratio or impedance ratio desired. Because of the extremely wide range of available chokes (0.10 μH to many millihenrys) in small increments, almost any ratio is obtainable.

It is also possible to use two chokes as primary and secondary of a transformer (Fig. 6F). Again, the wide range of values can be utilized for almost any transformation ratio. Depending upon the size and type selected (magnetically shielded types would not be suitable), the degree of coupling can be varied over a considerable range by adjusting the relative separation between the two choke bodies. If greater coupling is desired than can be obtained by mutual coupling, the usual methods of top *C*, top *L*, bottom *C*, or bottom *L*, as shown in Figs. 6F through 6J, can be utilized. However, because of the mutual inductance that exists between two chokes in close proximity to each other, additional coupling through a physical capacitance may actually reduce the effective coupling because one effectively tunes out the other (Figs. 7A and 7B). To prevent this from occurring, sufficient separation to minimize mutual coupling will give better control through the coupling elements, as indicated by Fig. 7C.

It is just this capability of being coupled to a coil or another choke that often requires that a choke be connected so that such coupling is at a minimum. Contrary to the usual v.h.f. and u.h.f. wiring practices, it is often necessary to use maximum lead lengths on chokes so that they may be placed away from tuned circuits or supply lines containing similar or different chokes. And because of the peculiarities of the distributed constants that make the choke what it is, the extra lead length has little effect on its performance. Furthermore, placing a choke near the chassis, although increasing the effective distributed capacitance somewhat, will provide a certain degree of shielding.

If the choke is magnetically shielded, so much the better, for such a choke will not only have little or no coupling to circuits but will also not radiate any r.f. to surrounding circuits as is possible with unshielded chokes. However, a note of caution is necessary. If a magnetically shielded coil is placed too close to a tuned circuit, it can effectively load, or lower, the "Q" of that circuit considerably because the closed ferrite body of the choke acts as if a shorted turn were coupled to it.

As a series element, a choke may also be used as a trap, either at its SRF or at some other frequency, by tuning it as a parallel circuit with additional capacitance. As such, it may be coupled to a circuit either magnetically or capacitively. As a series-tuned trap, the tuning capacitance should be large relative to the distributed capacitance of the choke so that the effect of the distributed capacitance is minimized. If the choke inductance is small, its effective inductance may be adjusted by the length of its leads, as much as 10%.

Chokes may also be used, because of the small physical sizes and wide range of inductances available, in the construction of miniature filters. A typical high-pass filter is shown in Fig. 7D. In a majority of cases, the capacitance required is large, the inductance values small, and the mutual coupling must be at a minimum. Magnetically shielded microminiature chokes, combined with miniature ceramic capacitors, can produce a high-pass, low-pass, or bandpass filter of incredibly small size yet with extremely sharp bandpass characteristics and large off-frequency attenuations.

Reliability

R.f. chokes, like all other components, must be selected with a bit of wisdom and a lot of understanding. In general, most standard makes of chokes will give satisfactory results even beyond their rated capabilities, although this is not a recommendation to use them in that way.

As long as chokes are operated within their intended ratings, and their specifications and intended applications are considered wisely, there should be no problems either in experimental use or in production.

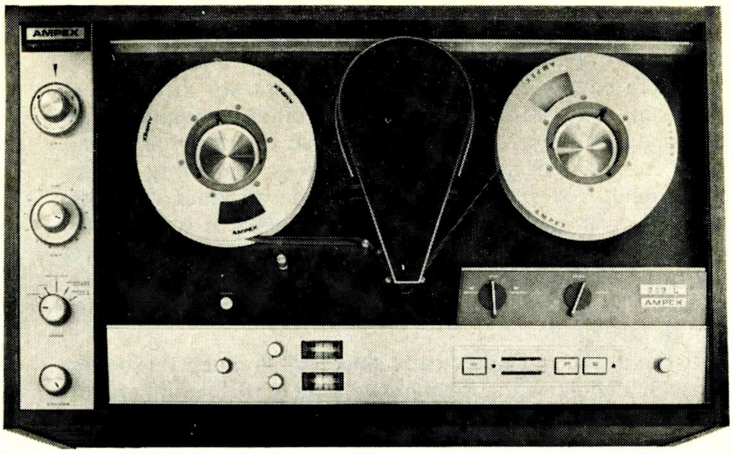
Recent impartial tests indicate that potted, cement-coated, or otherwise encapsulated coils tend to have a higher rate of failure as wire diameter is decreased. (*Continued on page* 68)

Inductance	Test Frequency (MHz)	SRF (approximate) (MHz)
.1-1.0 μH	25	500-164
1-10 μH	7.9	164-52
10-100 μH	2.5	52-15
.1-1 mH	.79	15-5.6
1-10 mH	.25	5.6-.47
10-100 mH	.079	.47-.115

Table 1. Self-resonant frequency is higher than test frequency.

Table 2. The relationship between choke and "Q" meter tuning.

Frequency Condition	Choke Reactance	Capacitance Dial
Below SRF	Inductive	Increase for resonance
At SRF	Resistive (Resonant)	No change
Above SRF	Capacitive	Decrease for resonance



Top view of the recorder. Control center is at extreme left.

Ampex Home Video Recorder

By JOSEPH ROIZEN / International Video Consultant, Ampex Corporation

Design and operation of this manufacturer's lowest priced full helical scan recorder for in-home, educational, and industrial uses.

VIDEO recorders utilizing magnetic tape as a storage medium are beginning to rival the already familiar audio tape units in size, price, and simplicity. The *Ampex* VR-6000 series, designed for home use, is an example of such a device. Its cubic dimensions, weight, and cost are roughly double that of a good-quality audio recorder.

The Model 6200 consolette, which includes deck, base, and video control center, costs $1495; the price of the Model 6100 basic deck alone is $1095. The control center contains TV receiver front-end circuits for making a recording but no display monitor. The center also permits the recorder to be connected to any TV set's antenna terminals to allow the set to be used as a monitor during playback. A separately available camera and microphone kit sells for $580. The recorder weighs just under a hundred pounds and will record and play back a 1-hour program using special 1-inch video tape. A 10-inch reel of this tape (3000 feet) costs $59.95, while a lighter duty tape is expected to cost $39.95 a roll. The video head used is expected to have a minimum life of 500 hours with a replacement cost of under $35. A tape made on one of these recorders can be played back on another similar *Ampex* recorder.

The VR-6000 uses the helical-scan principle with a single rotating head assembly (Fig. 1), laying down the 3° 6′ angled tracks containing the picture signal. Two stationary heads record the control and audio track signals in normal longitudinal fashion along the top and bottom edges of the one-inch-wide tape (Fig. 2). Although the tape moves from reel to reel at only 9.6 inches per second, the effective writing speed of the 3600 rpm video head is 1000 ips.

The tape is guided around the helical scanning assembly by entry and exit guides that can be opened to facilitate threading (Fig. 3). When the guides are in the closed position, the video head is out of contact with the tape for only

Fig. 1. A single rotating video head lays down very slightly slanted (3°6′) video tracks on the 1-in tape. Fixed heads record and play back control and audio tracks near tape edges.

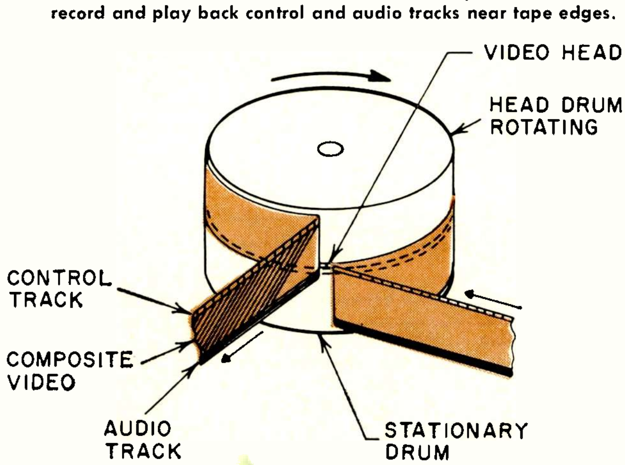
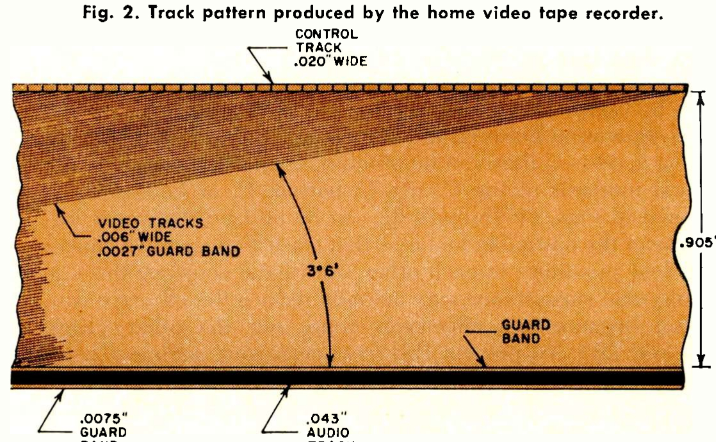


Fig. 2. Track pattern produced by the home video tape recorder.



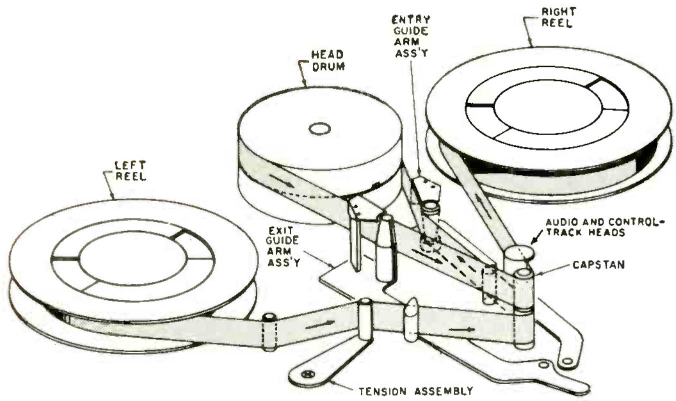


Fig. 3. During tape threading the guides are opened as shown.

a short time (a few horizontal lines) and this drop-out period is timed to occur just before vertical sync at the bottom of the picture where it is relatively invisible on the normally over-scanned monitor.

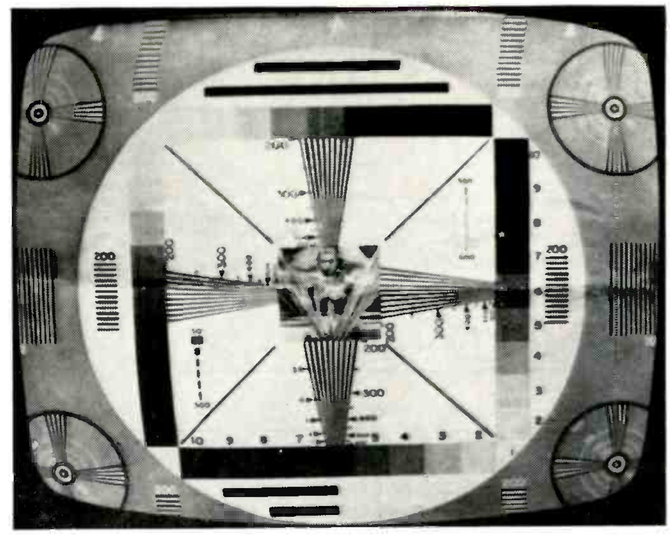
The only unusual controls on this recorder have to do with threading the tape and controlling its tension. A "Ready/Thread" knob opens the gates mentioned earlier. In the "Ready" position, the tape is tensioned by the holdback torque of the supply reel, but this may require slight changes to accommodate different tapes. A separate tension control knob actuates a pressure arm against the tape and varies the tape tension to optimize playback scanning of the video tracks. In the "Record" mode this tension arm is de-activated by a solenoid.

Although no specific control is provided for it, a feature not required on an audio machine is brought into play when the stop button is depressed. This is known as a "still-frame" presentation and presents a stop-motion image on the monitor screen whenever the recorder is in the play mode and as long as the "Ready/Thread" knob remains in the "Ready" position. The rotating video head then continues to scan the track representing a single TV field on the stationary tape. A slight pressure on the take-up reel will yield the best image, or permit moving slowly from track to track as the operator requires. In this way it is possible to pick out a single specific field that may be desired. The counter on the unit will permit rough location of any pre-recorded portion of the tape.

Signal System

Like most video recorders, the VR-6000 series utilizes a form of FM modulation which alters the character of the signal to be recorded from an amplitude varying one to a constant amplitude frequency variation. This greatly reduces the ratio between the highest and the lowest frequency to be recorded, thereby making the spectrum of recorded frequencies well within the read/write wavelength capabilities of the transducer. (The horizontal resolution of the played back picture is better than 250 lines while the video bandwidth is 20 Hz to 2.5 MHz.) The video input signal is applied through a video level pot which allows adjustment to a range of amplitudes normally encountered on a vidicon camera (Fig. 4).

The signal is pre-emphasized to improve signal-to-noise ratio and this pre-emphasized signal is then applied to a modulator operating between 3.0 and 5.0 MHz. A clamp in the circuit serves to maintain d.c. balance and to eliminate hum or tilt in the incoming signal. The output of the modulator is amplified and controlled so that the proper record current may be applied to the head. A final amplifier, known as a record driver, supplies the head current. The signal from the record driver is fed back to the playback circuitry so that monitoring of the incoming signal is actually done through most of the electronics of the recorder. This is known as the electronics-to-electronics signal and indicates that the system is functioning in the record mode.



Off-the-screen monitor photo showing played back test pattern.

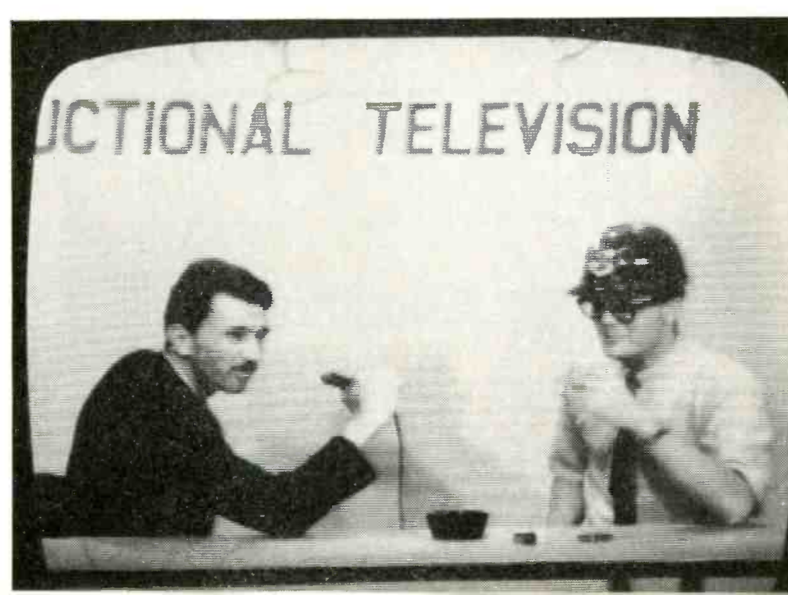
In playback, the video head output is connected to a high-gain preamplifier with equalization control. This is then fed to a series of limiters that maintain a constant amplitude output, even though the actual head output may be varying, due to changes in head-to-tape contact, drop-outs on the tape, etc. The output is detected and applied to a low-pass filter, which eliminates most of the FM carrier components and yields a video signal which is further amplified and applied to an r.f. modulator which can be adjusted to put out a composite television signal between channels 2 and 5 on a normal home receiver. The user selects an unused channel in his particular locality and he may then view the playback of his video-tape machine by switching his television receiver to that same channel.

Servo System

In order to control the timing of the television signal and the proper tracking of the rotating head on the video tracks, it is necessary to have a servo system in a video recorder. The function of the servo is to position the video head drum so that the tracks are written across the tape to some specific timing reference.

The vertical synchronizing signal is used as the reference and it is applied in the record mode to a pulse amplifier whose output is the sampling time for a signal derived from a tachometer head on the head drum (Fig. 5). The tachometer signal is delayed by a multivibrator and formed into a ramp

With the tape stationary, the rotating head scans the magnetic track corresponding to a single TV field. In the original photo scanning lines are clearly visible on close examination.



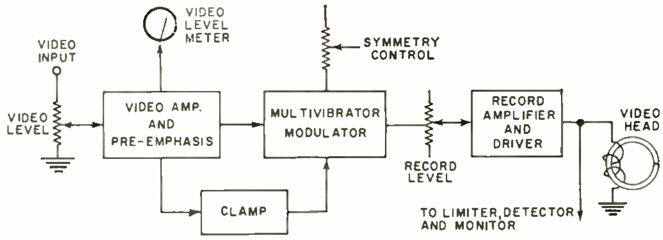


Fig. 4. Video signal circuits to the rotating video head.

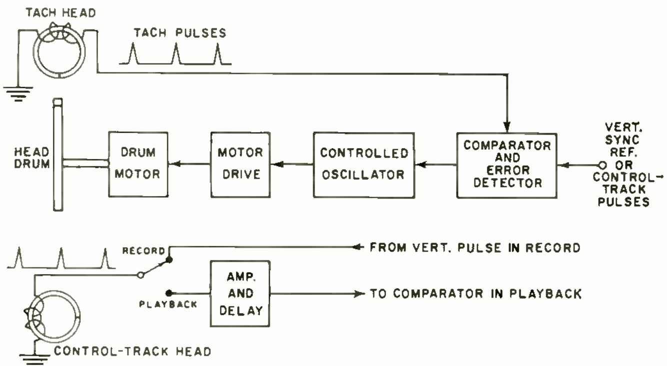


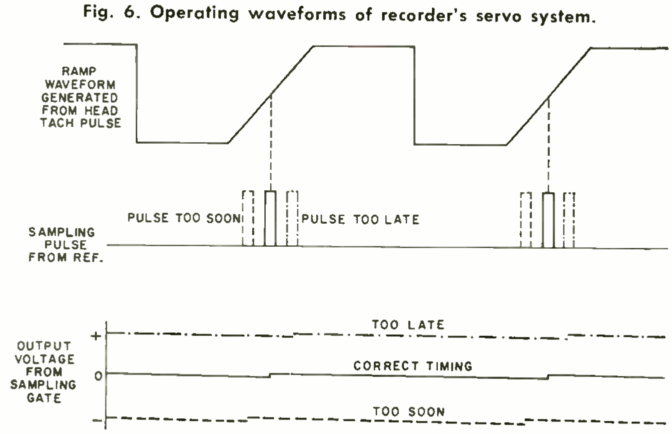
Fig. 5. Block diagram of the servo system which is employed to maintain proper speed so that video head tracks properly.

whose sloping gradient is proportional to the angular position of the drum motor. The ramp is sampled by the pulse derived from vertical sync and an error signal having the following characteristic is developed: the polarity of the error signal is the direction of the error and its amplitude is the magnitude. This voltage error then controls an oscillator which actually drives the drum motor through a binary counter and a power amplifier.

When the drum is in the wrong position, *i.e.*, the vertical pulse is not exactly at the right point on the tape, the sample pulse occurs too low or too high on the ramp signal (Fig. 6). Since the ramp evaluation at its center is zero volts, the sampling below or above this point applies a positive or negative voltage to the drum oscillator and the oscillator increases or decreases frequency proportionately. The drum motor accelerates or decelerates to minimize this error and when it achieves equilibrium, the sample pulses are centered on the ramp and the drum is now running at the right speed, properly positioned, and should continue to do so. This "lock-up" is achieved in a matter of a few seconds and a recording should not be initiated before this condition occurs. In the playback mode, the monitor image serves to indicate when the system is in synchronism.

While the recording is being made, the vertical sync signal is also being utilized to lay down an additional track along the top edge of the tape, referred to as the control track. This timing signal will be used in the playback mode to

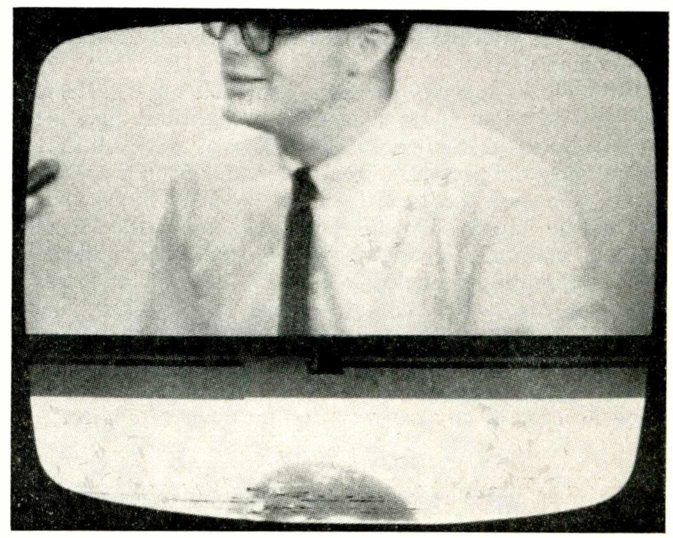
Fig. 6. Operating waveforms of recorder's servo system.



assure that the video head tracks accurately on the recorded signal. In playback, the control track head output is amplified and properly delayed through an adjustable multivibrator. This signal now becomes the sampling pulse for the drum phase comparator and the external reference is switched out of the circuit. The drum motor position is now being controlled by the coincidence between the control track and its own tachometer head. To adjust to optimum picture quality and minimum noise, a tracking control is included which alters the delay of the multivibrator driven by the control-track signal. If the delay is altered, the drum motor timing is changed until the playback signal quality is maximized. The capstan is locked to the power-line frequency since it is driven by 117-volt, 60-Hz a.c. power.

A single channel of audio is recorded simultaneous with the video signal, but displaced from it by the distance between the video-recording head and the stationary audio-head assembly. Since this distance is always fixed, synchronism is constantly maintained between the sound and picture.

The video recorder requires a low-impedance video signal at its input to provide the necessary electrical information. This is usually obtained from a camera if the recordings to be made are of local origination. However, for use in the home it is obvious that some means of taping shows off the air must be included so that the home viewer may record his favorite program while he is away, through the use of a pre-set timer. There is also the possibility that two desirable



Still-frame display with the vertical interval intentionally rolled up into view to show the dropout at the bottom of the picture while the rotating video head is leaving the tape.

programs may occur simultaneously and it would be useful to record one while watching the other. The recorded program can then be replayed at a more convenient time. To accommodate this, the system includes a video control center, which has a built-in tuner and a switching arrangement that permits input selection. The tuner is then set to the alternate channel and that signal is recorded while the desired channel is being watched. No modifications are necessary to the television set and the playback of the recorder is available on the selected channel, which is not in public use.

When the camera input is being used, the television receiver acts as a monitor and it is possible to carefully set up the home video recorder for optimum results. Switching the recorder into the play mode then provides an instantaneous replay showing that the television image has been properly transferred to the tape. In due time, tape libraries will carry pre-recorded video tapes which can be used for entertainment or information with the recorder. Especially in the educational field, this should be of great advantage for home-study courses of various kinds. ▲

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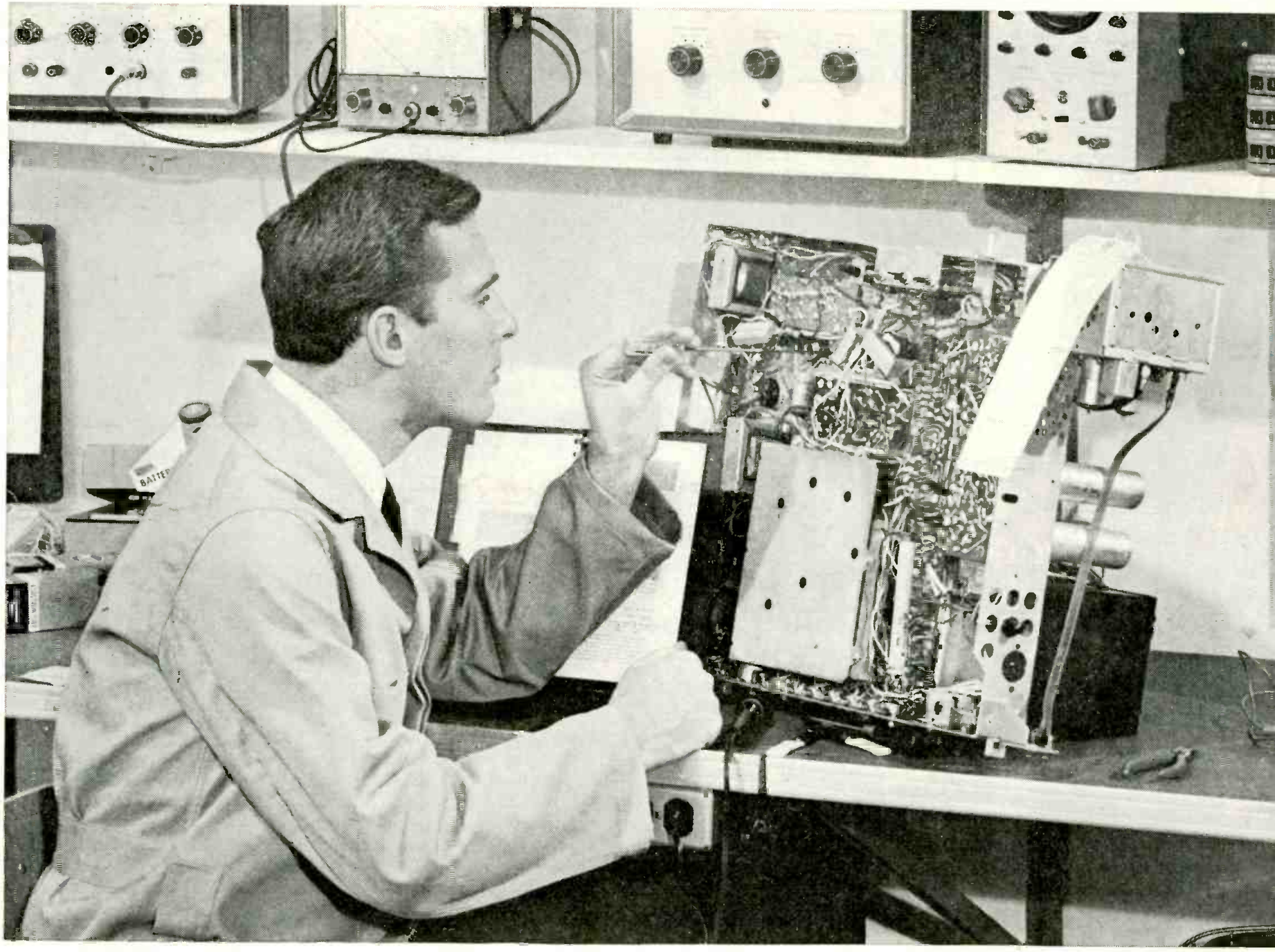

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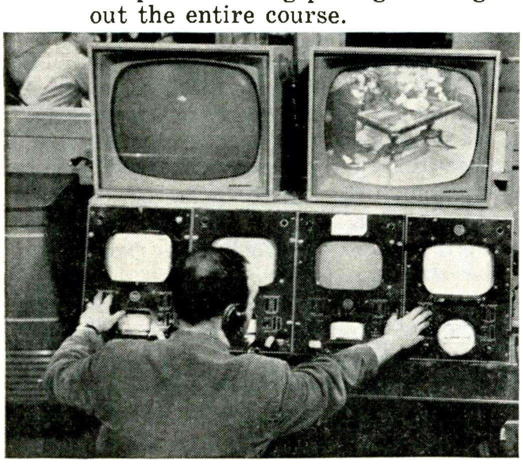

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THE TECHNICIAN AND THE YOUNGSTER

BARNEY pretended to be aligning the portable TV set on the service bench, but he was really cocking an ear to the conversation between Mac, his employer, and a freckled, shorts-clad boy holding a bulky radio in his thin arms and looking earnestly up into the face of the shop owner.

"Okay, kid," Mac said with assumed gruffness; "you told the office girl this was an urgent matter and that you had to see me personally right away. What's all this about?"

"Mr. McGregor," the boy said, "I'm in big trouble and I need help."

"What kind of trouble?"

"It's like this: I like to mess around with electricity and radio and stuff like that. Last night I got this bright idea—at least it seemed a bright idea then—of running a couple of wires from the voice coil of the speaker in this radio Dad keeps in his den down through the cold air register to another speaker above my workbench in the basement. Soldering on the wires was no sweat, and both speakers worked fine when I plugged in the radio; but when I tried to turn the radio off, the switch had no effect. The radio kept right on playing.

"What's more, when I moved the wires coming from the speaker, they made sparks where they touched the metal air duct, and this made a heck of a noise in the radio. I pulled the plug, cut off the wires going to my speaker, and sneaked out the back door with the radio. My dad will really clobber me if he finds out I've messed up this particular radio. You see, he's real proud of it because my big brother—he's in Vietnam now—bought it several years ago for Dad's birthday with the very first money he ever earned."

"A father *would* be pretty proud of something like that," Mac agreed, examining the thin cotton insulation on the two stiff wires sticking out through a hole in the cardboard back of the set. "What do you want me to do?"

"I want you to find what I did to the radio and fix it—no matter what it costs!" the boy blurted. "I've only got a dollar and thirty-five cents now, but I'll give you every penny of my allowance until I pay all of it—that is, if you'll trust me."

"I don't know about that," Mac demurred with pretended seriousness. "We don't do any credit work here. However," he went on hastily as he saw tears welling in the boy's eyes, "we may be able to work something out. First, let's find out how much damage you did."

He put an ohmmeter across the prongs of the line plug and clicked the switch on and off several times. With the switch on the meter indicated around 100 ohms; but each time the switch clicked off, the meter pointer fell back to an infinite resistance reading. Next, the switch still on, Mac checked for resistance between each of the line-plug prongs and one of the stiff wires coming from the speaker coil. One prong gave a reading of about 100 ohms; the other, zero resistance. Finally he plugged in the receiver. In a few seconds it began to play normally, and when the switch was turned off it quit playing. After waiting half a minute for the filaments to cool down, Mac turned the set back on and then off with the same results.

"Hm-m-m-m," he said, a twinkle in his eye that only Barney noticed, "I thought you told me the radio wouldn't turn off. By the way, boy, what's your name?"

"It's Tommy, and the radio *wouldn't* turn off. Honest it wouldn't. I wasn't lying to you."

"I know you weren't Tommy, and I also know you are a very lucky boy. This funny-acting radio could easily have killed you. Why do you think this notice is printed on the back of the set?"

"'*Warning: this receiver is equipped with an interlock switch for your protection. The back should be entirely removed before an attempt is made to change tubes,*'" Tommy read aloud. "I suppose they don't want you burning yourself on hot tubes."

"Huh-uh," Mac replied, shaking his head. "They don't want you electrocuting yourself. This is what we call a 'hot chassis' receiver. One of these line-cord wires goes through the switch directly to the metal chassis of the set. The speaker frame is bolted to the chassis, and one side of the voice coil is connected to the speaker frame; so, when the radio is playing, one of these wires you soldered to the voice coil is actually connected to one side of the 120-volt a.c. line. Do you know one side of that line is connected to the earth, both at the point where it enters your house and at the pole transformer out in the alley?"

"I know one wire is called a 'hot' wire and the other a 'ground' wire," Tommy admitted guardedly.

"Good. Now you know why. When you pulled the wire through the furnace duct, this cheesy insulation scraped off and made a connection from the radio chassis to ground through the wire, the metal duct, and the grounded furnace. Then you got lucky and inserted the plug in the wall socket so the wire leading through the switch to the chassis was connected to the grounded side of the line. That meant when the switch was on current could flow back to the pole transformer through either the ground wire or through the earth. Turning the switch off merely opened the wire circuit. Enough current still flowed through the earth circuit to keep the radio playing. Moving the speaker wires disturbed the electrical connection between the wires and the duct, producing the sparks and making the noise in the radio.

"Had you, while standing on the cement floor of the basement, touched the speaker wire and moved it so that it broke connection with the duct, the current would have flowed to ground through your body instead of through the furnace. That could have very easily been fatal."

Tommy's shoulders hunched together in a little shiver. "What would have happened if I had put the plug into the wall socket so that the hot wire went to the switch?" he asked.

"Well, as soon as you turned on the switch, the 120-volt line would have been short-circuited back through the earth circuit. A fuse would probably have blown, but before that happened you could have ruined the speaker or the switch in the radio."

While talking, Mac had been busy taking the back off the set, cutting loose the wires from the voice-coil terminals, and then buttoning the receiver back up. He arranged the line cord in a neat hank and handed the radio to the boy.

"How much do I owe you?" Tommy asked.

"I believe a dollar would be about right," Mac replied.

The boy fished a crumpled dollar bill from the pocket of his shorts and handed it to Mac. "I sure do thank you, Mr. McGregor," he called over his shoulder as he headed for the door. "This has really taught me a lesson I'll remember."

"Good kid," Barney commented when the boy was gone; "but I'd have bet you wouldn't charge him anything."

"That would have robbed him of his dignity," Mac explained. "He realized he'd made a mistake and was doing his best to rectify it like a man. Seeing this, I treated him like a man—as he wanted and deserved to be treated."

"You know," Barney observed, "for a man who never had a son you're a pretty understanding cuss. You make me a little ashamed of something I did last week. Three kids came to the house and wanted me to help them work out an electronic method for keeping tab on the flight of an experimental rocket they were building. They had some kind of a hazy notion about building a radar system to do this. Naturally, I told them this was out of the question, and I really gave them the old brush-off. My conscience has been pricking me about this ever since; and just now, when I saw you handling that youngster, it gave me a real jab. I'm going to get in touch with those kids tonight and see what we can work out that they can build themselves."

"Fine! I've always felt a man fortunate enough to acquire a fund of technical knowledge has a sort of obligation to share that knowledge with youngsters who seek and need his help. You might call it a kind of intellectual *noblesse oblige*. I never forget that if one man hadn't been kind and understanding to me when I was a kid I'd probably not be in electronics."

"Who was that?" Barney asked.

"He operated a combination garage and one-horse motion picture show back in the little Arkansas town where I was born. I was fascinated by the 32-volt *Delco* system he used to charge storage batteries and to furnish power for the theater house lights and the carbon-arc light in the projector. I kept pestering him until he finally showed me how to care for the two-volt glass cells and to operate that *Delco* d.c. generator. I think the proudest moment of my whole life was the first time he let me press that little black tongue that actuated the starter of the gas-driven generator."

Mac paused a few seconds to enjoy the fond memory and then continued. "He always had several spare cells, and he'd let me take two or three of these home at a time for my experimenting. When they were exhausted, I'd simply exchange them for freshly charged cells. You can't imagine what it meant to have an unlimited supply of electricity with which to experiment back in those days of coal-oil lamps. I built my own electric magnets, motors, bells, induction coils, and even a telephone. After that, electricity and I were married for life."

"I know what you mean," Barney said. "When I was a kid I haunted the home of a radio ham who lived just behind us. He used to say jokingly that he expected to find me sitting on his doorstep when he took in the milk and when he put out the cat. But he took the time and trouble to answer my questions, to lend me books, and to help me learn the code. That man helped me find what I wanted to do for my life's work."

"There's a lot of satisfaction and a lot of responsibility in encouraging a youngster to become involved in electronics," Mac mused. "The satisfaction is pretty well wrapped up in that remark that a man never stands so tall as when he stoops to help a child. As for the responsibility, you have to begin with, and keep harping on, the dangers of electricity. As we just saw, a little knowledge is truly a dangerous thing in this business, and it is not in the natural disposition of a youngster to worry about what *might* happen; yet that is precisely what a person must do constantly when he's working around electricity. When you're working with something that moves 186,000 miles a second, anticipation of trouble is your only protection."

"Hey, Boss, I just happened to think that I am a good example of what you have been talking about. If course I'm not a kid any longer, but you have certainly spent a lot of time and patience on me over the years. Just about everything I know about electronics you've taught me. I hope that gives you a little satisfaction."

"Oh I'm not *too* ashamed of you," Mac said with a teasing grin. "Considering what I had to work with, I've done fairly well!" ▲

"It seems her telephone and TV both went out at the same time."

Ultrasonics in Medicine

(Continued from page 29)

of lesion which produced them. Tomograms have successfully differentiated among several different types of benign and malignant breast tumors and some researchers feel that it is quite possible that the not too distant future will see ultrasound used for routine diagnostic screening of the breast in the same manner that chest x-rays are now used for mass screening for tuberculosis.

Systematic ultrasonic studies of the extremities have revealed that it is possible to depict and identify the skin surface, the fatty layers, the muscle groups and their fibrous sheaths, the blood vessels and even thickness of their walls. An interesting application of ultrasonic tomography not directly connected with medicine has been the evaluation of the quality (*i.e.*, fat content and distribution) of the flesh of animals selected for breeding purposes.

The development of convenient, portable contact scanners has greatly simplified the application of area B-scans to obstetrics. Excellent visualizations have been obtained of the fetus and its position in the uterus and these ultrasonic tomograms have been used to demonstrate the presence of multiple pregnancies and of several types of abnormalities.

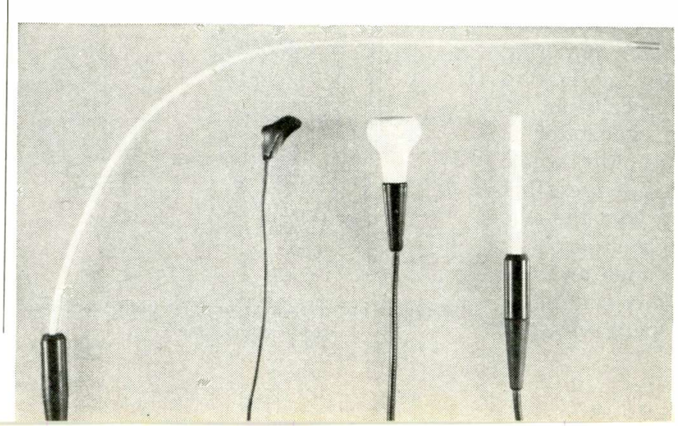
Recent improvements in the sensitivity and convenience of ultrasonic transducers and scanning apparatus, as well as improvements in the technique and greater sophistication of the interpretations have made it possible to extend the use of ultrasonic tomography to the direct visualization of intracranial tumors. In this technique, described by Dr. Adapon of the New York University Medical Center and Dr. Grossman of the University of Pittsburgh School of Medicine, a motorized scanning bridge moves a transducer at a predetermined rate on the surface of the skull. As in all B-scans, display apparatus is switched to the intensity modulation mode which produces a signal whose brightness is proportional to echo amplitude. As the transducer moves along the surface of the head, a corresponding line of dots moves vertically over the screen of the oscilloscope. Position of the transducer is displayed on the vertical axis and the distance of the echo from the skin surface on the horizontal axis. The shutter of the recording camera is left open throughout the scan and results in a two-dimensional image of a cross-section of the head in the plane of the moving transducer. On these images normal and abnormal intracranial masses have been visualized directly and not merely by inference as they are in the time-amplitude scans of the midbrain structures. This technique is new and most American research up to now has been done on *known* lesions. However, clinical researchers are hopeful that enough studies on unknowns will be done in the next few years to yield diagnostic results acceptable to the medical profession.

Surgical Application of Ultrasonics

The third major area of medical ultrasonics—that of the destruction of diseased or unwanted tissues—is still further from broad medical utilization but is already being used in certain specific procedures. One of these is the selective destruction of the vestibular function of semicircular canals of the inner ear in the treatment of acute forms of Meniere's disease. This disorder is characterized by severe ringing of the ears, vertigo, and nystagmus—an uncontrollable side-to-side motion of the eyes.

In this treatment a special focused transducer is placed directly on the surgically exposed semicircular canal and driven at 3 MHz. This frequency produces rapid attenuation of the signal and thus limits its penetration to the desired area. Ultrasonic energy, applied at intensities of 3 to 8 watts per cm^2, destroys the diseased or malfunctioning epithelial cells in the labyrinth without damage to the hearing. This treatment has had a high percentage of success in thousands of cases in Italy, where the technique has been pioneered by Dr. M. Arslan, of Padua, as well as in the Presbyterian Hospital in New York.

A considerable amount of experimental data has already been accumulated at the University of Illinois and several other biomedical research centers on the selective destruction of small volumes of tissue within the brain. Using focused multiple ultrasonic radiators and



Various types of ultrasonic transducers. From left to right: transducer mounted at end of long, flexible probe; finger-tip transducer for examination of exposed organs; general-purpose 2-MHz transducer for external examinations; pencil-type 7.5-MHz transducer to provide narrow beam to locate foreign bodies.

intensities of 50 to 1500 watts per cm^2, researchers have been able to produce precisely placed lesions as small as one mm^3 at 1 MHz and as small as 0.02 mm^3 at 2.7 MHz.

Such minute and precisely positioned brain lesions have been produced for treatment and relief of intractable pain, the tremors and rigidity of Parkinson's disease, and the involuntary athetoid movements associated with cerebral palsy. Prefrontal ultrasonic irradiation has been used as a substitute for lobotomy and further possible application is indicated for the treatment of psychomotor epilepsy.

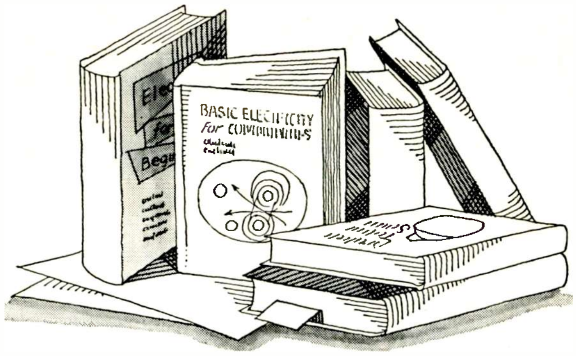
The specific and particular advantages of high-intensity ultrasonic neurosurgery are varied. The precise location of the unwanted tissue can be checked by the disappearance of the symptoms at lower sonic intensities—before ultrasonic energy of sufficient intensity to destroy the tissue permanently is applied. Precisely controlled ultrasound is able to destroy brain tissue without affecting any of the surrounding or even contained blood vessels and, of course, to reach deep-seated internal areas without damaging the intervening tissues. However, although ultrasonic energy will penetrate the skull for ordinary diagnostic purposes, precise surgical procedures on the brain require the removal of portions of the bone through which sound beams are to pass in order to minimize scattering and obtain more precise control. To obtain accuracy within a few thousandths of an inch, human neurosurgical apparatus possesses extreme rigidity. To prevent motion during the irradiation procedure the skull of the patient is held by stainless steel pins with hemispherical ends which fit into shallow hemispherical depressions drilled in the skull.

While the most dramatic applications of ultrasonics to medicine have been in the areas described, these by no means exhaust its usefulness. Among the ancillary medical and biological applications are several ultrasonic methods for measurement of blood flow and viscosity.

It has been pointed out that the comparative rates of the growth of our population and of the production of physicians make it inevitable that the present ratio of one doctor to every 790 persons will decrease to one to a thousand by 1980.

However, this decreasing ratio of doctors to patients does not mean a decline in the adequacy or quality of medical care. On the contrary, there is every indication that the improvement in medical technology, the development of new drugs, and the utilization of advanced electronic systems and devices will provide even better medical care. Ultrasonics in its many applications will certainly provide an important modality to make this possible. ▲

BOOK REVIEWS



"DICTIONARY OF ELECTRONICS" by Harley Carter. Published by *Hart Publishing Company, Inc.*, 510 Sixth Ave., New York, N.Y. 10011. 410 pages. Price $2.65. Soft cover.

In order to meet the needs of students and engineers in the fast-changing field of electronics, this concise, illustrated, and inexpensive dictionary has been prepared.

The terminology is British, but American users should experience little difficulty in making the transition. Priority has been given to the inclusion of fundamental facts and terms and the other entries follow on from these. Also listed are familiar terms and descriptions of many electronic instruments. Definitions cover many branches of electronics, including radio, television, communications, radar, electronic instrumentation, and industrial electronics.

A rather extensive appendix includes circuit symbols, abbreviations, color codes, conversion tables, and tube basing diagrams.

* * *

"TRANSISTORS: PRINCIPLES AND APPLICATIONS" by R. G. Hibberd. Published by *Hart Publishing Company, Inc.*, 510 Sixth Ave., New York, N.Y. 10011. 297 pages. Price $5.95 cloth bound, $2.45 soft cover.

The author, manager of the R&D Department of *Texas Instruments Ltd.*, offers a comprehensive guide to the characteristics and uses of the various types of transistors that have been developed in recent years. Included is information on the junction transistor, the epitaxial planar, the field-effect, metal-oxide silicon, and thin-film types. He discusses the principles of operation, transistor characteristics, equivalent circuits and parameters, and how to establish suitable d.c. operating conditions. There is even a chapter devoted to the manufacture of transistors so that the effects of the basic methods of fabrication and types of junction on transistor characteristics can be easily understood.

The operation and characteristics of associated semiconductor devices used in conjunction with transistors, such as the junction rectifier, the silicon controlled rectifier, the zener diode, the tunnel diode, the varactor diode, and the phototransistor are also covered.

The book also includes notes on handling and testing transistors and a chapter on solid-state circuit techniques.

The lavish use of line drawings, partial schematics, graphs, and charts helps to explain the text material. While the author is associated with *Texas Instruments Incorporated's* British affiliate, most of the information and circuitry will be easily recognized by American engineers and students.

* * *

"THE RADIO AMATEUR'S HANDBOOK" compiled and published by the *American Radio Relay League, Inc.*, Newington 11, Conn. 602 pages plus 32-page tube section, index, and 56-page catalogue section. Price $4.00 in U.S. Soft cover.

This is the forty-third consecutive edition of the "amateur's bible" and represents a veritable treasure trove of useful information for the ham, engineer, and student of radio and electronics.

The chapters on the theory of radio communications have been updated to keep abreast of all phases of the art while material on equipment construction has been revised to take advantage of new design techniques. There are transmitter and receiver circuits for every amateur frequency range, and for special purposes such as mobile and portable operation. Theory and construction material is included for other important ham station equipment such as test and measuring instruments and antennas.

The chapter on vacuum tubes and semiconductor characteristics and tube basing diagrams has been brought up-to-date and provides one of the most complete such listings to be found within a single book.

* * *

"1966 WORLD RADIO TV HANDBOOK" compiled and published by *World Radio-Television Handbook Co. Ltd.*, Denmark. Available in the U.S. from *Gilfer Associates*, P.O. Box 239, Park Ridge, N.J. 07656. 304 pages. Price $4.95 postpaid. Soft cover.

Another harbinger of Spring is the appearance of the new annual edition of WRH. This is the 20th such edition and includes a complete listing of medium- and short-wave stations (including TV), frequencies, broadcast schedules, interval signals, addresses, station personnel, etc.

Of interest to SWL's is information regarding verification of reception reports, or lack of verification, for the various stations, what form verification takes, and correct mailing addresses of the various stations.

Maps, musical intervals for identification purposes, world time schedules, abbreviations used, etc. are extras which make the handbook especially useful. Incidentally, television stations (including location, call letters, and channel) are listed for the U.S., Canada, and Mexico.

* * *

"TRANSISTOR ELECTRONICS" by Karl-Heinz Rumpf & Manfred Pulvers. Published by *Pergamon Press Inc.*, 122 E. 55th St., New York, N.Y. 10022. 282 pages. Price $10.00.

Subtitled "Use of Semiconductor Components in Switching Operations," this book is devoted almost exclusively to applications in digital systems and, as such, is designed primarily for design and development engineers and students of advanced electronic techniques.

The book contains extensive circuit and logic diagrams as well as many practical, worked examples. A large part of the book is devoted to semiconductor data, including standardization, rationalization, life-expectancy, and serviceability of components.

Since the authors have addressed this book to fellow engineers, they have assumed that their readers have the requisite background in mathematics and circuit theory. The translation from the German by Werner Stohl is excellent.

* * *

"DAVID SARNOFF" by Eugene Lyons. Published by *Harper & Row*, New York. 359 pages. Price $6.95.

This is an "in depth" portrait of one of the electronics industry's best known figures. The author traces Mr. Sarnoff's life and works from his birth in Uzlian, a tiny isolated village in Russia, his emigration to the United States, his life in the ghetto of New York's Lower East Side and then Hell's Kitchen, and his struggle upward to head one of the largest electronic firms in the world.

The eldest child in his family, young David had to take over as the head of the house when his father died not long after the family emigrated. The range and variety of the jobs he tackled is impressive and gives some clue to the man to come.

There are long and detailed accounts of litigations, suits, countersuits, and contract negotiations which may be of less interest to the general reader than the details of Mr. Sarnoff's life and accomplishments but are a necessary part of the well-rounded picture of the man and his creation, *RCA*. ▲

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CIRCLE NO. 85 ON READER SERVICE CARD

SOVIET "POLAR-MODULATION" STEREO

A simple demodulator, reduced costs, and extra subcarriers are claimed for system.

USING a technique very similar to the American pilot-tone system of transmitting and receiving stereo broadcasts, Soviet engineers have been testing what they call the "polar-modulation" system of compatible stereo.

The basic difference between the two systems is that while the American method completely suppresses the 38-kHz modulated subcarrier, and transmits a 19-kHz pilot tone, the Soviet system does not transmit a pilot tone and only suppresses its 31.25-kHz subcarrier by 14 dB.

Both systems are capable of reproducing 30 to 15,000 Hz on either channel. Crosstalk attenuation above 300 Hz is better than 25 dB. Deterioration in the S/N ratio with A=B for mono transmission is 2 dB while for stereo reception it is 22 dB (compared with the 1 and 19 dB for the American system).

The Soviets also point out that in countries where a frequency deviation of ±75 kHz is in force, their system can also permit (besides stereo) another subcarrier at 55 ±5 kHz, and an SCA-type service at 67 ±7 kHz, while still staying within the allowed 75 kHz.

The polar-modulation system modulates the subcarrier such that the positive half cycles of the subcarrier are modulated by one channel while the negative half cycles are modulated by the other channel (see insert in Fig. 1). At the polar-modulation receiver, the composite signal is detected and passed on to a stereo adapter such as shown in Fig. 1. Here, the incoming signal is passed through a filter peaked at the subcarrier frequency, amplified, and then passed through a cathode follower to a simple polarity detector. The output from the detector is then passed to external audio amplifiers.

Because the polar-modulation subcarrier is twice the frequency of the European TV horizontal line frequency, Soviet engineers point out that their system can easily be put to use in broadcasting stereo signals over a TV sound transmitter. In this case, the subcarrier itself does not have to be transmitted because it can be regenerated from the TV set line oscillator. The reduction in S/N ratio (with A = B) in the stereo channel is 0 dB in mono and 16.4 dB in the stereo mode. ▲

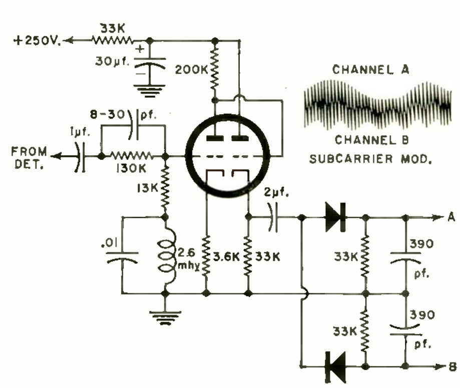


Fig. 1. Simple stereo adapter uses polarity detectors. The insert shows method of subcarrier modulation.

Chroma Demodulation

(*Continued from page 47*)

are simultaneously present at the three electron guns.

The actual circuitry used in all recent *RCA* color sets performs exactly the same functions as required by the matrixing principles but appears much more complex. As shown in Fig. 8, the matrixing circuits consist of three triode amplifiers which have their cathodes connected together. To make sure that no color signals appear during the retrace period, a blanking pulse is applied through *C*6 to the junction of the cathodes, cutting all three triodes off.

The exact amplitudes and components of *X* and *Z* at the various tube elements are quite complex to analyze because both signals are present at cathodes and plates. The important point is the principle of adding signals of various amplitudes and polarities.

In the $R-Y$ stage, the $-X$ signal is applied to the grid, but a portion of the plate signal is fed back, through *R*1, slightly reducing the amplification. The $R-Y$ signal requires a large $-X$ and a much smaller $+Z$ signal. Looking at the $B-Y$ amplifier, note that the $-Z$ signal is applied at the grid, making the *Z* signal at the cathode positive. Because the cathodes are connected together, the $R-Y$ amplifier will have a small $+Z$ signal at the cathode which is then added to the $-X$ signal applied at the grid.

As shown in Fig. 7, $G-Y$ is made up of $+X$ and $+Z$ signals. The $G-Y$ amplifier then receives a $+Z$ signal on its cathode, but it also receives a $+X$ signal on its cathode since all three cathodes are tied together. Note that the $+X$ is larger than the $+Z$, and therefore a portion of the $+X$ from the plate of the $R-Y$ amplifier is applied to the grid of the $G-Y$ stage through *R*5 and *R*6, which act as a voltage divider. At the $B-Y$ amplifier, the $-Z$ signal must be considerably larger than the $+X$ and the $-Z$ is therefore applied to the grid, while $+X$ appears at the common cathodes.

Another way of analyzing the operation of the matrixing amplifiers would be to think of signals applied at the grid as having more amplitude, because of the gain inherent in the control grid, while those signals applied at the cathode would have a lower amplitude. We can say that $+X$ and $+Z$ appear at the cathode while $-X$ and $-Z$ appear at the grids of the $R-Y$ and $B-Y$ stages. The $G-Y$ amplifier receives both $+X$ and $+Z$ at its cathode, but since the $+X$ must be larger, an additional component is fed to the grid from the $R-Y$ amplifier which acts as an inverter for the $-X$ signal. ▲

R.F. Chokes

(*Continued from page* 51)

Encapsulation tends to restrict the thermal expansion of the windings due to the different expansion rate of the encapsulating material. These tests indicate that such a restriction causes the wires to bite through the insulating coating and short adjacent turns together. However, these tests also show that the failure rate only increases rapidly above #34 AWG and at temperatures in excess of 150°C. Furthermore, most encapsulated chokes use materials that do not hinder expansion of the windings since the materials are, to a wide degree, either compatible in expansion coefficients or are thermosetting and tend to soften slightly with elevated heat.

How to Measure

Any of several instruments may be used to determine the various characteristics of r.f. chokes. The necessity for doing so, however, will depend upon what kind of information is made available by the manufacturer and just what interpretation can be made of this information.

The approximate SRF (self-resonant frequency) may be found quite simply with a grid-dip oscillator, provided the choke is not completely magnetically shielded. If more than one dip is observed, the lowest frequency indicated will be the fundamental SRF. With this set-up, you can then alter this frequency with additional shunt capacitance, meanwhile monitoring the change until the desired frequency has been reached.

For any type of choke, shielded or not, a "*Q*" meter can be used to determine the SRF and, simultaneously, the distributed capacitance and the "*Q*" at the SRF. This last point is often overlooked in the application of a choke and the use of the available data. A careless reading will lead the user to believe that the "*Q*" shown is at the SRF, when it is actually the "*Q*" that is obtained at the frequency *of measurement* at which the *inductance* measurement is made on the "*Q*" meter. Only at the given test frequency does the "Inductance" dial read correctly, but the test frequencies for the various inductance ranges differ from the SRF by a factor of 2 to 20 in the normal range of miniature choke values. The differences for one make of choke are shown in Table 1. It is obvious from this table and from the vast differences in "*Q*" for the same coil at various frequencies that one measurement cannot substitute for the other. Of course, the "*Q*" may not be important in many applications, but where it plays a significant part, it must be determined for the SRF or the frequency at which it is to be used.

The SRF is measured on the "*Q*" meter by the following procedure. Connect the test leads to the "Cap" terminals. With the choke disconnected and the leads in place, connect to the "Coil" terminals a relatively high "*Q*" work coil that will resonate in the region of the expected SRF of the choke. The choke is then connected to the test leads on the "Cap" terminals and the "Capacitance" dial is tuned to re-resonate the combination. If no change is necessary, then that frequency is the SRF of the choke. If the "Capacitance" dial must be shifted to re-resonate, then the entire procedure must be repeated, but at a higher or lower frequency until the SRF is found. As a guide, Table 2 shows the relationships among the various indications.

The effective parallel resistance R_p and effective parallel reactance X_p at any frequency may be found by a similar method, except that the process used to pinpoint the SRF is not necessary.

Adjust the "*Q*" meter for resonance at the test frequency F and record the indicated "*Q*" as $Q1$ and capacitance as $C1$. Remove the test leads from the "Cap" terminals and record the increase in capacitance needed to re-resonate the "*Q*" meter as $C2$. Reconnect the leads and the choke to be measured, and re-resonate at F. Call the new reading $Q2$.

The effective parallel resistance is found from $R_p = [(1.59 \times 10^5)(Q1Q2)] / [f(C1+CL)(Q1-Q2)]$ and the effective parallel reactance is found from $X_p = (1.5 \times 10^5)/f(C2-C1)$ where f is in MHz and C is in pF. The impedance is $Z = \sqrt{R_p^2 + X_p^2}$ at any frequency, and $Z = R_p$ at the SRF since $X_p = 0$ and $R_p = \sqrt{R_p^2}$.

Under some conditions $(C2-C1)$ may be negative, indicating a capacitive reactance for the choke at that frequency.

The "*Q*" is found from "Q" $= [(C2-C1)(Q1Q2)]/[C1(Q1-Q2)]$ and is the "*Q*" of the unknown impedance, or in this case the choke being tested. This is obtained from the relation "Q" $= R_p/X_p$.

The distributed capacitance may be measured with the "*Q*" meter by the two-measurement method when the distributed capacitance, C_d, is 10 pF or less, as follows.

Connect the choke to the "Coil" terminals and resonate the choke by varying the "Frequency" dial, with the capacitance set at a low value (30 to 50 pF). Note the frequency and call this capacitance $C1$. Change the frequency setting to one-half the previous frequency setting and re-resonate the coil by varying the "Capacitance" dial. The new value is called $C2$. The distributed capacitance, within 20%, is found by $C_d = (C2 - 4C1)/3$.

A much simpler method of determining the approximate value of C_d is from a resonance chart, where frequency, inductance, and capacitance are shown. As long as C_d is small, it has a negligible effect on all but very small values of inductance. For this reason, the *apparent inductance* will be close to the *true inductance*, and the chart would probably show the required capacitance to resonate the apparent inductance with as good an accuracy as the "Q" meter.

For example, a 10-μH$\pm$10% choke measured by the above method had an *apparent inductance* of 10.7 μH and a distributed capacitance of 0.67 pF. The "Q" at SRF was not measured because the SRF was above the range of the "Q" meter.

From a resonance chart, the apparent inductance given in the manufacturer's data sheet gives a capacitance value slightly higher.

The actual inductance that would be measured *if the choke had no distributed capacitance at all* is found from the value obtained in the C_d measurement.

The true inductance is $L_T = L_A[C_1/(C_1+C_d)]$. In the case of the 10-μH choke just mentioned, $L_T = 10.7\ [38/(38+.67)] = 9.83\ \mu$H where C_1 is the capacitance required to measure the apparent inductance, 38 pF in this case; and L_A is the apparent inductance.

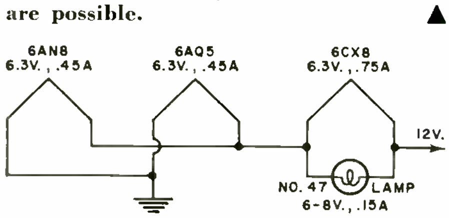
Thus, the SRF can be determined from the values of L_T and C_d, or the approximate C_d can be obtained from the approximate SRF and a resonance chart. Because of the nature of r.f. chokes and their various circuit requirements, these approximations will quite often be adequate. ▲

FILAMENT SHUNT

By CHARLES C. MORRIS

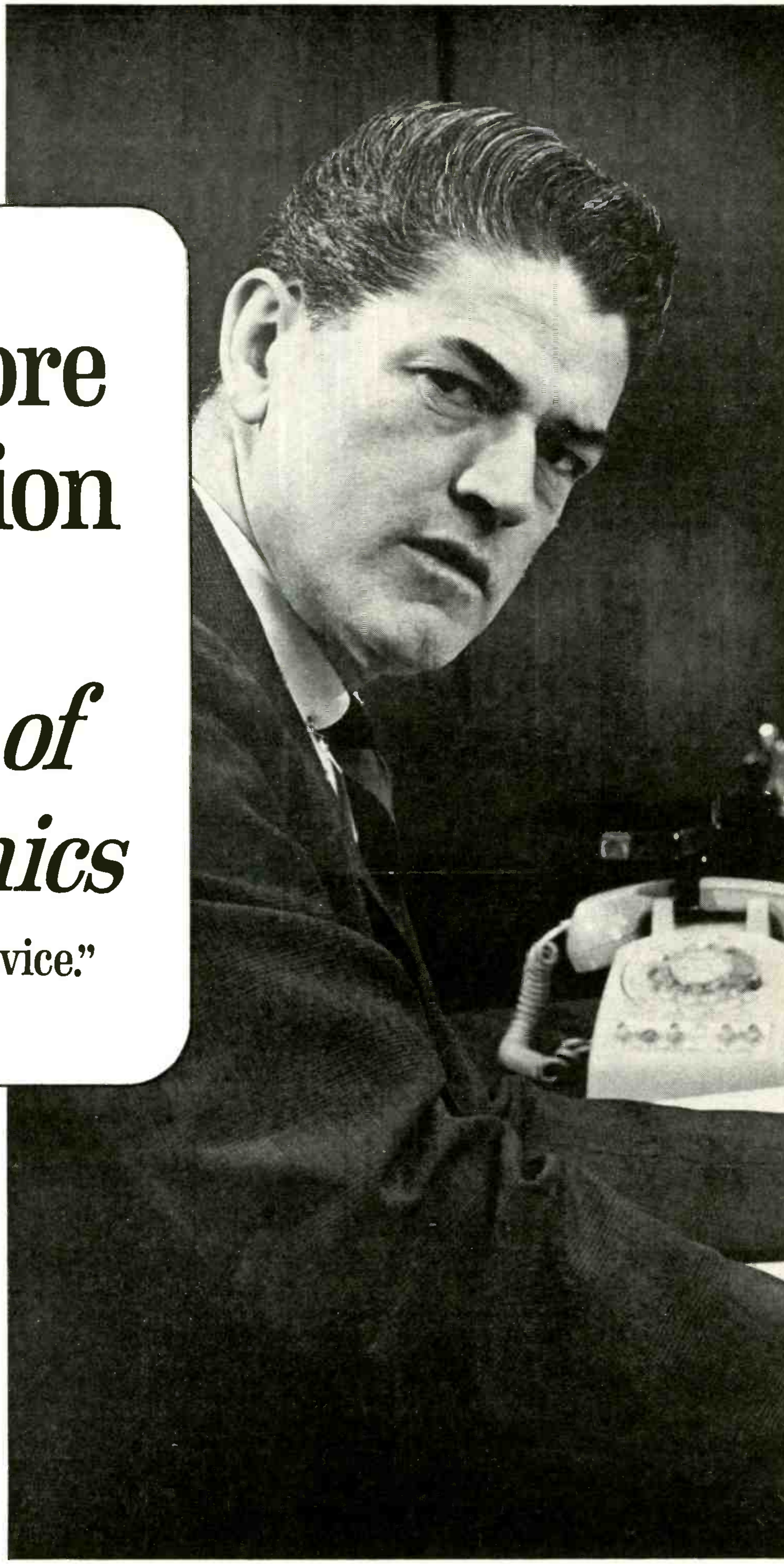
QUITE often the filament string of 12-v. d.c. mobile equipment requires the use of series-parallel wiring and filament shunt resistors. A typical circuit might use a 6CX8, 6AQ5, and 6AN8. These tubes cannot be wired for 12-volt operation without filament shunting provisions.

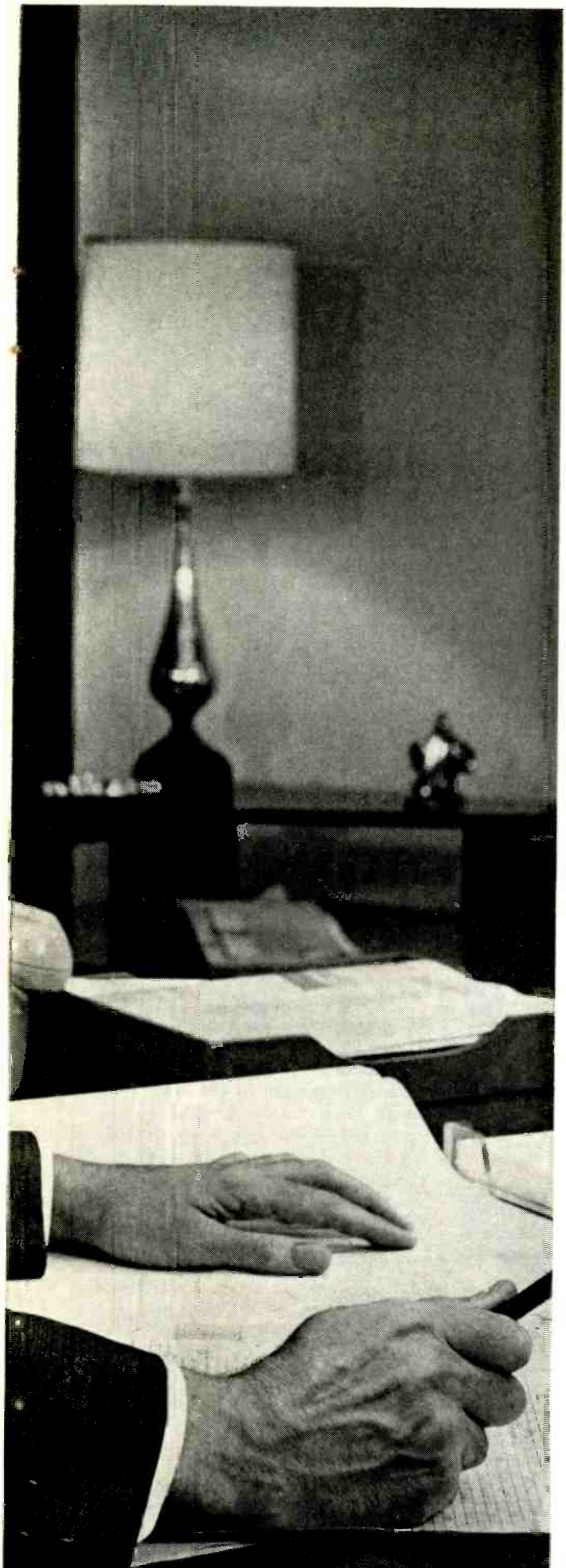
A simple solution is shown in the illustration. This makes use of a standard pilot lamp that can also serve as a panel light. For example; a #47 lamp (6.3-v., .15 a.) can be wired in parallel with the 6CX8 making that combination operate at 6.3-v., .90 a. The 6AQ5 and 6AN8 tubes are connected in parallel making that combination also operate at 6.3-v., .90 a. The two combinations are wired in series for 12-v. operation. The lamp could be used as a panel lamp (power-on indicator). Many other combinations are possible. ▲



"Get more education or *get out of electronics*

...that's my advice."





Ask any man who really knows the electronics industry. Opportunities are few for men without advanced technical education. If you stay on that level, you'll never make much money. And you'll be among the first to go in a layoff.

But, if you supplement your experience with more education in electronics, you can become a specialist. You'll enjoy good income and excellent security. You won't have to worry about automation or advances in technology putting you out of a job.

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AIRLINES PLAN COMMUNICATIONS SATELLITES

World-wide v.h.f. coverage is envisioned in this approach.

THE Air Transport Association of America, representing the interests of American commercial aviation, has been conducting a number of experiments using communications satellites for signaling between high-flying aircraft and their base stations.

The airlines are interested in the possibility of using satellites for air-to-ground communications because this offers the most promising way to get reliable static-free v.h.f. communications over vast ocean areas. V.h.f. is used for communications with aircraft in flight over the U.S. and within line-of-sight range of coastal or island stations for transoceanic flights. At the altitudes of 30,000 to 40,000 feet commonly used by jets, line-of-sight distance is not usually more than 250 miles (less than a half-hour's flying time) but can be extended to about 350 miles using increased transmitter power.

With the introduction of supersonic transports, contact time between stations may amount to only a few minutes. When it is considered that an enormous amount of information (usual communications, navigation data, and telemetry) will have to flow between the SST and the base station, then a very reliable means of long-distance, interference-free communications must be used.

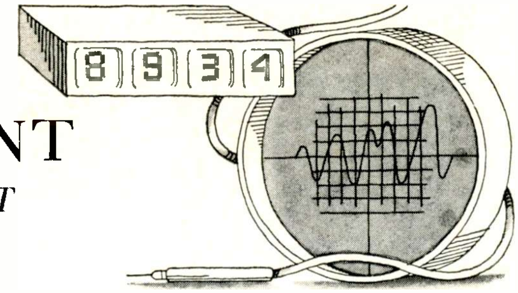
Beyond the range of v.h.f. stations, the aircraft presently relies on high-frequency (h.f.) communications which are more severely affected by sunspots and other disturbances in the earth's ionosphere. H.f. achieves its range by bouncing signals off the ionosphere; thus, daily and seasonal changes in the position and intensity of the ionosphere affect such communications. The difference in communications quality between h.f. and v.h.f. is considerable.

By providing a stationary satellite radio-relay link, such as a synchronous satellite, more than one-third of the earth's surface becomes line-of-sight.

In a series of tests initiated by the ATAA, using the Syncom III satellite over the Pacific Ocean, teletypewriter transmissions between 6¼ and 50 words per minute were exchanged between an aircraft and ground station.

In one test, a *Pan American* aircraft climbing out of Hong Kong successfully maintained v.h.f. contact with a base station in California, better than 6000 miles away. ▲

TEST EQUIPMENT
PRODUCT REPORT



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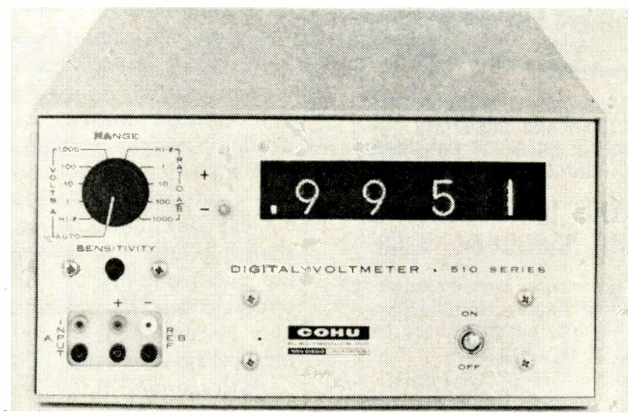


A NEW family of highly accurate, solid-state digital voltmeter-ratiometers, the 510 Series, has been developed by *Cohu Electronics, Inc.* combining the d.v.m.'s inherent superiority for making rapid, precise, accurate measurements free of interpolation errors with the flexibility of general-utility bench meters. The addition of a digital coupler creates an inexpensive digital data-logging system for recording on typewriters, tape punches, or standard office adding machines.

First to be introduced in this new series is the Model 511. It is designed to be used as a general-purpose d.c. voltmeter and d.c./d.c. ratiometer. Its high accuracy (0.01% of reading, ±1 digit) and wide measurement range (100 microvolts to 1000 volts and 0:1 to 1000:1 ratios) make this instrument suitable for use in R&D, calibration, and test laboratories; in repair and maintenance facilities; and in any other application where the resolution and accuracy are needed or where a clear numerical display will eliminate reading errors and reduce test time. Specific applications include low-voltage measurements where loading effects cause excessive errors. The meter has virtually infinite input resistance on the lowest voltage range. The floating input reduces possibilities for error due to grounding currents.

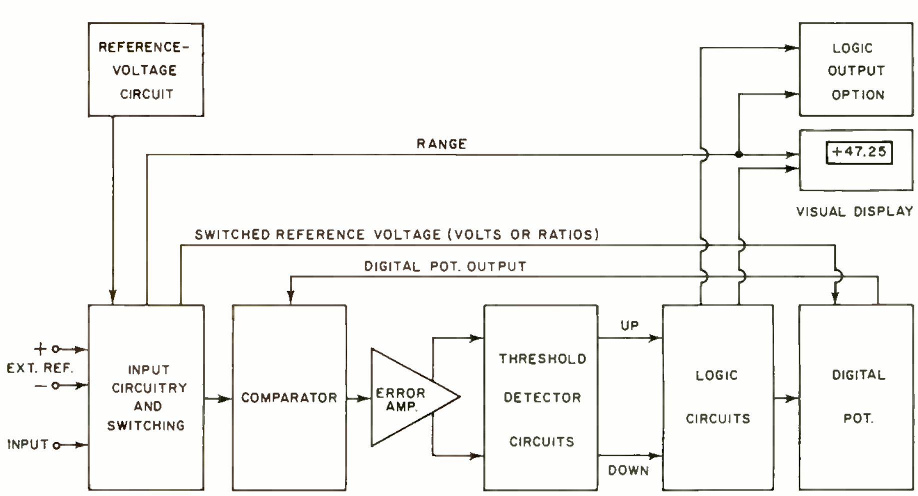
A front-panel switch selects both the measurement range and function (voltage or ratio), and a sensitivity control stabilizes measurements in the presence of noisy input signals and permits use of external reference voltages greater than one volt. Four decaded ranges for each function enable measurement of d.c. voltages from .0000 to ±999.9 volts and d.c./d.c. ratios from .0000:1 to ±999.9:1. Accuracy is 0.01% of reading, ±1 digit for both voltage and ratio measurement. Input resistance is 10 megohms on all but the 1-volt and 1:1-ratio ranges where a choice is provided of either 10 megohms or greater than 1000 megohms.

Principal design characteristics (see block diagram) include a bidirectional, tracking-type logic which balances faster for small signal changes than most d.v.m.'s having a single-pass logic system. Biquinary logic is used for both the digital potentiometer and the readout indicator switching and results in a reduction of components. Use of plug-in printed-circuit relays in the logic circuitry further reduces component count because each multi-pole relay performs simultaneous logic, digital potentiometer switching, and readout control functions. Conversion from the biquinary code used in the 511 to commonly used BCD codes requires only simple decoding matrices.

Precision low-temperature-coefficient wirewound resistors are used in the range divider and in the digital potentiometer to achieve very high accuracy and stability of both voltage and ratio measurements. A stable solid-state reference voltage source provides an accurate reference for voltmeter operation. The visual display uses biquinary-input, glow-discharge numerical indicators. These have a wide viewing angle (approximately 150°) and a bright red neon glow.

In operation, voltages present at the input divider and digital potentiometer outputs are sampled in a comparator circuit. Any difference in the two potentials appears at the input to the error amplifier as an error pulse. The error amplifier is a low-noise, solid-state circuit. An error amplifier sensitivity control allows use of external reference voltages from ±1 volt to ±100 volts.

Power consumption is only 15 watts. Dimensions are 5¼" x 10½" x 15", and weight is just 12 pounds. The price is $995. ▲



Hewlett-Packard Model 427A Multi-Purpose Voltmeter

For copy of manufacturer's brochure, circle No. 157 on Reader Service Card.

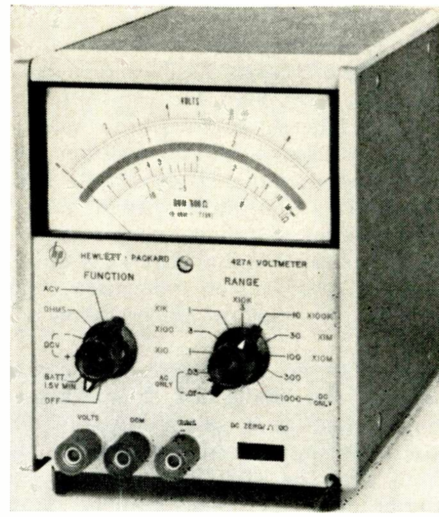
A NEW high-impedance multi-function meter, with all solid-state circuitry, battery-operated, with a mirror-backed, individually calibrated taut-band meter movement, has been introduced by *Hewlett-Packard* at just under $200.

The Model 427A is a d.c. voltmeter (full-scale ranges: 100 mV to 1000 V), and an a.c. voltmeter for the frequencies from 10 Hz to 1 MHz (full-scale ranges: 10 mV to 300 V), with ±2% full-scale accuracy. The a.c. response is proportional to average, and the meter is calibrated in r.m.s. values. Ohms ranges, ±5% accurate, are 10 ohms center-scale to 10 megohms center-scale.

The heart of the meter is a new d.c. amplifier using a field-effect transistor both for high input impedance conversion and, through a balancing circuit, for temperature compensation. Input resistance is above 10 megohms. The d.c. drift with temperature is typically under 0.5 millivolt per degree centigrade.

Battery power makes possible complete isolation from power-line ground. The common signal ground is floated and may be operated as much as 500 V d.c. off ground. A single 22.5-V internal dry battery, inexpensive and readily available, is the normal power source. The instrument's low power consumption (400 milliwatts) gives the battery typical continuous-operating life of more than 300 hours. Built-in facility to operate also from the a.c. power line is an option. With this option, the instrument may be switched instantly from a.c. to battery, or *vice versa,* while in use.

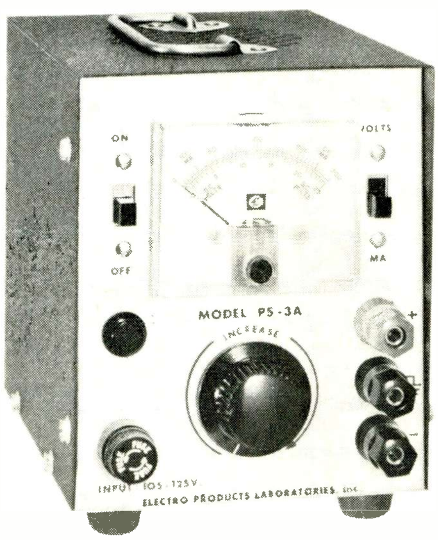
Both a.c. and d.c. volts are measured



from the same terminals. Since the d.c. mode strongly rejects a.c., separate measurements of a.c. and d.c. voltages at a common point may be made at the flick of the function knob. Overloads are well tolerated: 1200 V d.c. causes no harm on any d.c. range setting; 300 V r.m.s. a.c. are withstood without damage even on the most sensitive a.c. ranges, while 425 V are withstood on ranges above 1 V. ▲

Electro PS-3A Transistor Regulated Power Supply

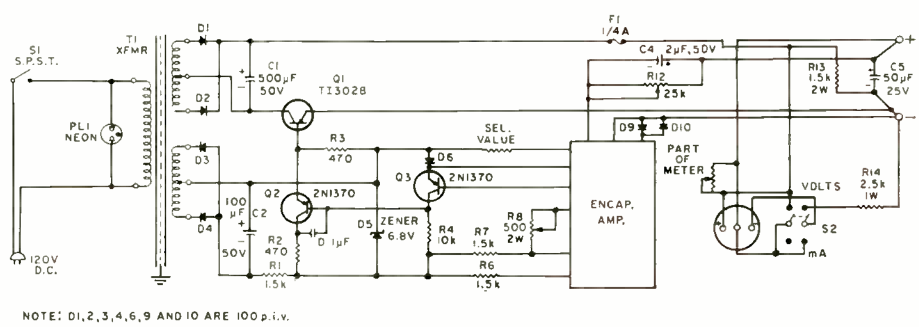
For copy of manufacturer's brochure, circle No. 158 on Reader Service Card.



THE Model PS-3A power supply, manufactured by *Electro Products Laboratories, Inc.,* is a general-purpose, low-power laboratory supply that provides an adjustable source of ripple-free, stable d.c. power from 0 to 25 volts at up to 200 mA. The output-voltage adjustment resistor (*R*12 in diagram) is a 12-turn potentiometer that permits very accurate setting of the output voltage and prevents serious disturbance of the output setting if the adjustment knob is accidentally touched. The unit has an output ripple of 0.5 mV and a line or load regulation of 0.02%.

The supply has many industrial laboratory applications and can be used for classroom demonstrations and for battery substitution. Both positive and negative output terminals are "floating" so that either may be connected to the chassis ground terminal. The isolation of the output terminals permits series operation of two or more supplies for higher output voltage.

The supply uses a basic series transistor voltage regulator and a regenerative feedback amplifier. This combination



NOTE: D1, 2, 3, 4, 6, 9 AND 10 ARE 100 p.i.v.
ENCAP. AMP. (INCLUDES Q4, Q5, D7, D8, R9, THERMISTOR)

forms a closed-loop current amplifier. By changing the impedance of $Q1$ inversely with the load current, a constant voltage is maintained across the output terminals. Instead of using a zener diode as the main reference element, a conventional silicon diode ($D8$), operated well into its characteristic "knee" in the forward direction, is used. This results in a low temperature coefficient and a low dynamic impedance, equaling or exceeding the performance obtained from a considerably more expensive zener regulating diode.

Transistors $Q2$ and $Q4$ are used for current amplification. The error-sensing amplifier is a differential amplifier consisting of $Q4$ and $Q5$. This latter circuit, along with the reference diode and a thermistor, are encapsulated within a single epoxy block. The increased thermal capacity of the epoxy reduces the effects of temperature "spikes" so that the amplifier and thermistor respond evenly without overshooting or hunting. Silicon diodes $D9$ and $D10$ prevent overdriving the differential amplifier during sudden load changes in excess of ratings by clamping the input to the forward drop across the diodes.

The built-in meter can be switched to monitor either output voltage or current. The price of the power supply is $99.50. ▲

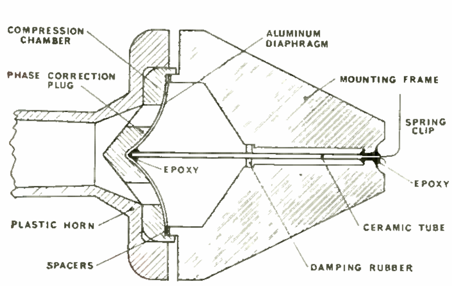
SOLID-STATE TWEETER

THE usual high-frequency loudspeaker (tweeter) uses a fine wire coil mounted on the piston of a horn, placed in a magnetic field, and excited by passing an electric current through the coil.

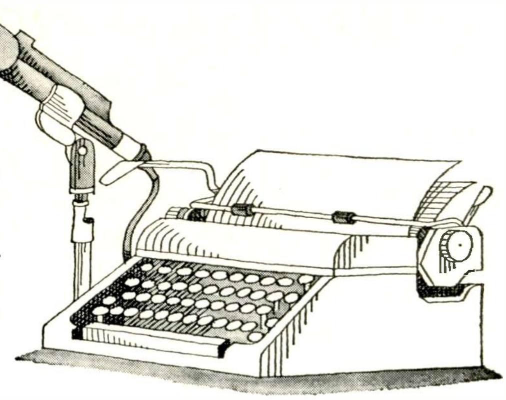
In a newly designed horn by Motorola, a piezoelectric ceramic element powers a driver piston that "kicks" small pulses of air through the horn. A cross-section of the new loudspeaker is shown in the illustration.

One end of the piezoelectric ceramic element (developed by Clevite Corp.) is cemented to the apex of a flower-shaped aluminum diaphragm. The other end is connected to two wires, one on the outside and the other on the inside surface of the ceramic tube.

As voltage is applied and removed from the ceramic, it expands and contracts over its entire length to act as a power driver pumping the diaphragm back and forth. This action drives pulses of air through the horn. ▲



RADIO & TV NEWS



THE development of the techniques of creating integrated circuits may lead to a small-sized, portable electronic device that will enable the blind to tactually "read" any printed material rather than conventional Braille only.

Basically, the system suggested by J. G. Linvill of Stanford University and J. C. Bliss of the Stanford Research Institute consists of a finger-tip-sized dense array of tiny photocells, each coupled to its own transistor amplifier and each fed to an independent piezoelectric bimorph reed that can produce tactile stimulation. The internal circuit is arranged so that a darkened photocell gates the output of a tiny oscillator to the corresponding reed. Thus, the plane of reed tips, some stationary and some vibrating depending on whether each photocell receives light or not, generates a tactile image of the material being "read."

The blind person, acquainted with the physical formation of the printed letters and numbers, places a finger tip over the plane of reed tips and moves the reading aid over the printed material.

As the various reed tips come into play with the changes in color density between the background and printing, the user can sense a vibrating and grainy facsimile of the material being read.

Successful reading tests with blind subjects have been made using a computer to simulate the reading aid. These tests showed that the tactile images presented on a field of 96 piezoelectrically driven pins have been readable by three tested subjects at rates of about 30 correct words per minute.

Present photocell sensitivities and integrated circuit techniques appear to be adequate for a convenient microminiature realization of this arrangement, although several technical problems remain to be solved.

Time Signals

The high accuracy of the WWV-type time signals is very useful in precision laboratory work. However, for the general public, the time signals transmitted by various radio and TV stations suffice.

A check of the timing systems used by the New York area network stations showed that *NBC* uses a system of three coincident gates (one for hours, one for minutes, and one for seconds), all driven from a precision clock checked to WWV twice a day. When the three gates are coincident (on the hour), a relay closes to place the time tone on the line. *CBS* uses an audio oscillator triggered by a precision clock which in turn is compared and corrected to WWV. *ABC* radio uses a *Western Union* clock correction signal, sent each hour, to close a relay that puts their tone on the line. Most of the local radio stations also use the *Western Union* correction signal for initiating their tone, chime, or gong.

Single-Slot Telephone

A new coin telephone, completely new in appearance and with a single-slot coin entrance, is going into service in many parts of the country. Developed at *Bell Labs.*, the new unit should save time for the customer by eliminating any possible fumbling in getting the right coin in the right slot. Unlike previous coin telephones, there are no gongs or chimes as the coins are deposited. Instead, electronic signals, not heard by the customer, indicate the number and type of coins deposited. This system also permits future automation of the telephone system.

The coin chute accepts non-mutilated U.S. coins, including the new laminated types, and will reject fraudulent ones. As each coin enters the chute, it is tested for ferromagnetic properties, maximum diameter, minimum diameter, maximum thickness, weight, density, and resistivity.

Electronic Match

A novel use for an SCR was recently unveiled by the *Wilcolator Co.* The pilot light of a gas range is removed, and the SCR-controlled "electronic match" substituted. Operating like an automobile transistor ignition system, when a push-button is depressed, a spark jumps across a gap located in the burner's gas flow igniting the gas. According to the manufacturer, this new system enables cold operation of a gas range without the danger of a pilot light blowing out with possible resulting damage. ▲

Resistive Attenuators
(*Continued from page 37*)

At the higher losses these become too low for practical manufacture. The approximate maximum loss normally supplied in the T and balanced-H attenuators is 60 dB but here again the actual maximum depends upon impedance and dB per step.

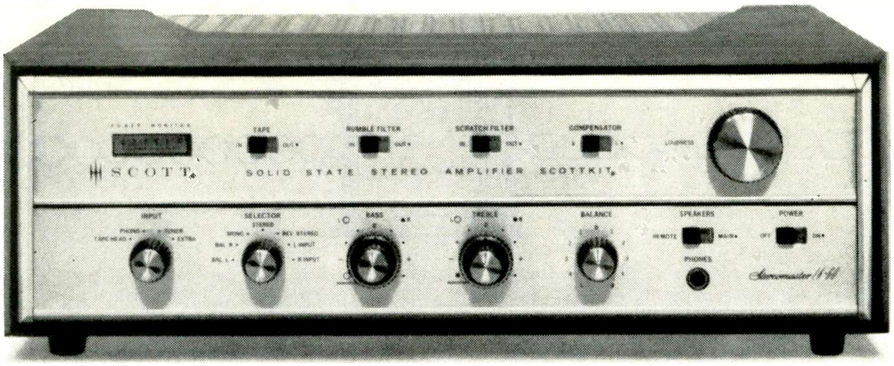
In the above types the total attenuation range of a variable attenuator may be increased by combining two or more attenuators on the same shaft and connecting them in series. For example, a 100-dB attenuator can be made by connecting two 50-dB attenuators in series. In operation, the first group of steps varies the first 50 dB and the second group of steps varies the second 50 dB. Up to 50 dB, the attenuation is varied in one section while the second section remains at zero dB. Above 50 dB the first section remains at 50 dB while the second section inserts the remainder of the attenuation.

In ladder and balanced ladder attenuators the circuitry is such that the resistor values do not get too high or too low as loss is increased and therefore they are not a limiting factor in the dB range. Thus, in these types, attenuation ranges of somewhat over 100 dB are obtainable.

Attenuators are available covering the frequency range from d.c. to 10 GHz. So-called audio-frequency attenuators will operate satisfactorily up to at least 100 kHz and in some instances, depending upon the decibel range and impedance, much higher. Video-frequency attenuators generally operate at frequencies up to 10 MHz and radio-frequency attenuators cover the remainder of the range to 10 GHz.

Attenuator accuracy is dependent upon the accuracy of the resistors used in their construction. At audio frequencies, the attenuation accuracy is the same as the resistor accuracy. Thus, if resistors with a 5% accuracy are used, the attenuation will be within 5% of nominal. Actually the attenuation accuracy will probably be much closer than 5%.

Attenuators used in broadcasting and recording operations normally have a 5% accuracy while those used in instruments and in measuring applications generally have a 1% accuracy and frequently have tolerances as close as 0.1%. The higher frequency attenuators normally have the accuracy specified in dB through a range of operating frequencies. Since this accuracy depends upon the amount of loss, impedance, and frequency range, a general statement of available accuracies is not feasible. For these applications the manufacturer should be consulted before completing an equipment design.



With the exception of a few covering fixed high-frequency types and two or three covering attenuation networks (two or more attenuators connected in series and mounted in a portable case or on a relay rack panel), there are no MIL-Specs on attenuators. However, attenuators are available which will meet most of the military environmental requirements such as: temperature extremes, humidity, shock, vibration, and salt spray. For detailed information, the manufacturer should be consulted.

Attenuator Ordering Information

Most attenuator manufacturers have catalogues which show the electrical and mechanical specifications of their "standard" attenuators. When items are required which are not included in the catalogue, the information supplied to the manufacturer should be as complete as possible to avoid delay or misunderstanding. As much as possible of the following information should be included.

1. *Complete electrical specifications* including whether the attenuator is to be fixed or variable. If fixed, include type of circuit, decibel loss, impedance (both input and output), required accuracy, frequency range, and operating level (power).

If variable, include type of circuit, impedance (both input and output), required accuracy, frequency range, operating level (power), number of steps and dB per step, linear or tapered, are "off" or "cue" positions required? (both input and output terminated but no signal goes through).

2. *Mechanical specifications.* If fixed, include maximum physical size (if space is important), and type of terminals and connectors.

If variable, include physical size or manufacturer's basic type, with or without detents (indexing device), any required shaft deviations from manufacturer's standard, and type of terminals or connectors.

Finally, specify any military requirements which must be met. ▲

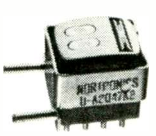
QUICK AND EASY BREADBOARD

By CHARLES C. MORRIS

A NOVEL breadboard circuit idea is to use squares of soft pine wood and unpainted thumbtacks for mounting the experimental circuit. The thumbtacks can be soldered very easily, making excellent terminals and component tie-points.

The thumbtacks have the added advantage that they can be used over and over again and, by using soft pine wood, many multi- or odd-circuit arrangements can be made up—a thing not always possible with commercial breadboard components.

Another idea is to use the thumbtacks simply as component hold-down devices if for some reason direct soldering would be undesirable. ▲



SEMICONDUCTOR INTERVAL TIMER

By DONALD E. LANCASTER

Semiconductor gate-controlled switch makes practical an all-electronic timer that can be set from 1 to 100 seconds in discrete 1-second steps.

THERE have long been available simple, low-cost timing devices of various types, ranging from mechanical egg timers, neon and thyratron devices, simple *RC* relay and SCR circuits, to others. Practically all of these devices leave much to be desired in the areas of convenience of operation, repeat accuracy, timing precision, life, resettability, and ease of external connections.

The new semiconductor gate controlled switch (GCS) makes practical an all-electronic digital timer capable of 1 to 100 second timing in discrete one-second intervals, to an over-all accuracy of better than 2 percent. The device is self-resetting, and has very quick recovery. It can be operated, read, and cycled in total darkness either manually or *via* external foot switches. There are no relays or other mechanical components in this circuit which will directly control 25 to 500 watts of 117-volt incandescent lamp load. Simple modifications allow the control of any load, either all-electronically or *via* an external relay. Operation is absolutely silent. No warm-up time is required and only a brief half-second recovery time is required for high repeat accuracy.

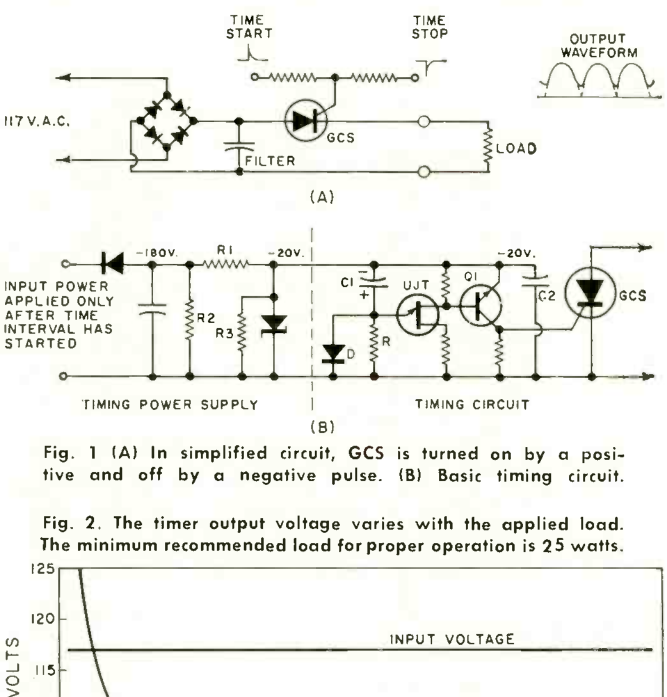
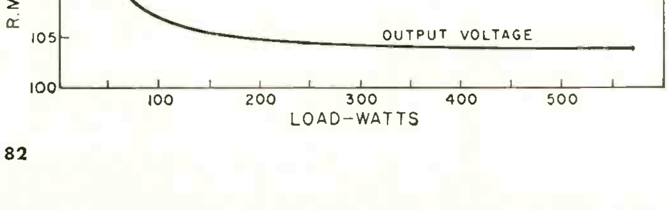


Fig. 1 (A) In simplified circuit, GCS is turned on by a positive and off by a negative pulse. (B) Basic timing circuit.

Fig. 2. The timer output voltage varies with the applied load. The minimum recommended load for proper operation is 25 watts.



This timer was specifically designed for use as an enlarger control center for a custom photo finisher and thus lends itself well to most darkroom applications. There are many non-photographic applications for this device, ranging from sequence timers for displays, electronic automatic checkout equipment, process control, to other applications requiring the accuracy and ease of operation not found in many other control devices.

Parts cost should not exceed $45 and no special tools or components are needed to build this unit.

Operation

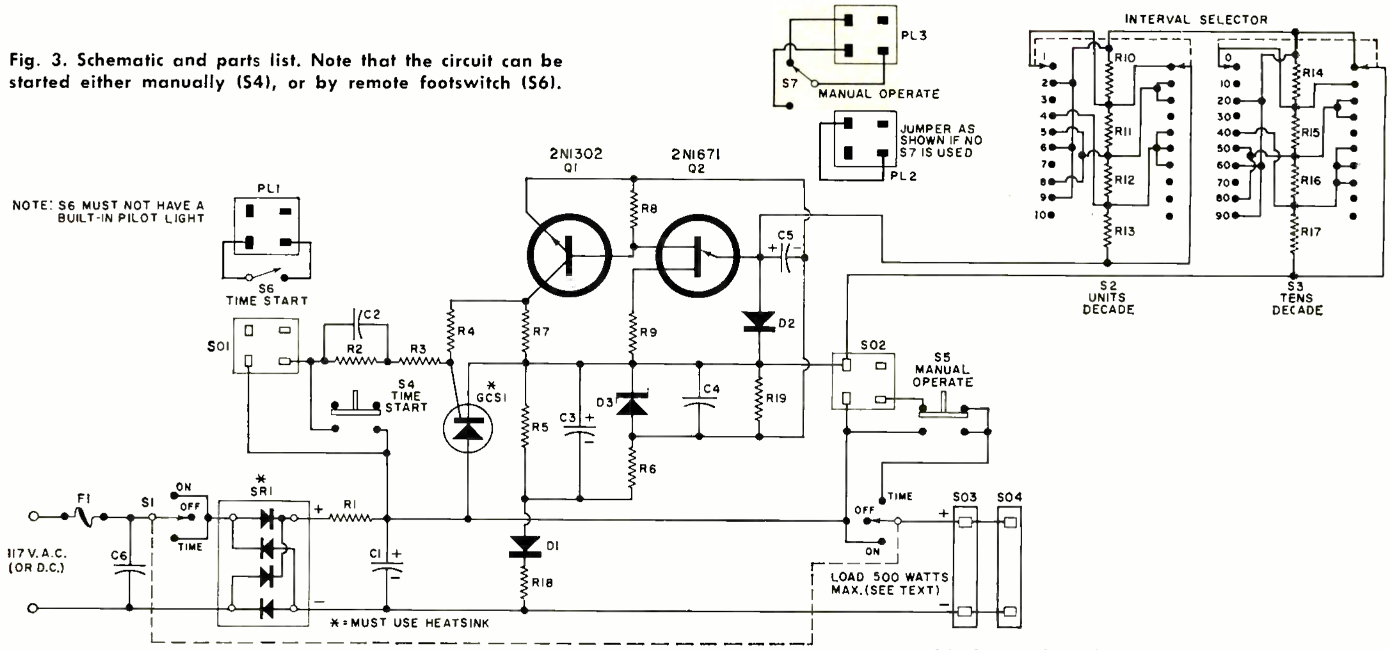
The basic circuit consists of a bridge rectifier, a gate controlled switch, and a zener-stabilized transistor-unijunction timing circuit. This is combined with suitable switching that provides for momentary or sustained load power in addition to the normal time cycle.

A gate controlled switch is the new SCR-like device with the added advantage that the GCS may be turned off, as well as on, by gate pulses of the proper polarity. Since these are unilateral devices, a full-wave bridge rectifier is required for the GCS and the load. Fig. 1A shows the simplified power-control circuit, while Fig. 1B shows the timing circuit. The output of the rectifier is filtered only enough to provide holding current for the GCS during the zeros of the a.c. line. This produces the waveform shown in Fig. 1A across the load. Once the GCS is pulsed on, it latches on, and stays on cycle after cycle until a negative gate turn-off pulse appears. The amount of filtering used must be a compromise between providing enough holding current at high loads, and the rising output voltage that will be provided under light load operation. (With very small loading, the output would be pure d.c. at 1.41 times the normal line voltage.) When a 20-μF filter capacitor is used, loads of between 25 and 500 watts may be accommodated by the timer. The output voltage varies somewhat with large changes in load, as shown in the regulation curve of Fig. 2.

In operation, a "Time-Start" pulse turns on the GCS and the load. The GCS turn-on also provides power for the timing circuitry. At the end of the time interval, the timing circuit produces a turn-off pulse, shutting down the GCS, load, and timing power supply.

The timing circuit (Fig. 1B), consists of a zener-regulated power supply and a unijunction transistor. An *RC* network between the -20V line, the emitter of the UJT, and the circuit common provides the time function. In operation, the charge across *C*1 (Fig. 1B) is zero at the start of the time period. Resistor *R* starts charging *C*1 and the emitter voltage of the UJT gradually becomes more and more positive. When a critical emitter voltage is exceeded (the intrinsic stand-off ratio), the UJT abruptly turns on. This also turns on the gating transistor (*Q*1) which "dumps" the charge on *C*2

Fig. 3. Schematic and parts list. Note that the circuit can be started either manually (S4), or by remote footswitch (S6).



R1—1 ohm, 5 W wirewound power res.
R2—2.2 megohm, ½ W res.
R3—3300 ohm, ½ W res.
R4,R18—47 ohm, ½ W res.
R5—18,000 ohm, 2 W res.
R6—5000 ohm, 5 W res.
R7—470 ohm, ½ W res.
R8—39 ohm, ½ W res.
R9—510 ohm, ½ W res.
R10—Selected value to give exactly 1-sec time interval (approx. 17,000 ohms, ½ W, see text)
R11—2 × R10, ½ W res. ±1%, see text
R12—4 × R10, ½ W res. ±1%, see text
R13—3 × R10, ½ W res. ±1%, see text
R14—10 × R10, ½ W res. ±1%, see text
R15—20 × R10, ½ W res. ±1%, see text
R16—40 × R10, ½ W res. ±1%, see text
R17—30 × R10, ½ W res. ±1%, see text
R19—2400 ohm, ½ W res.
C1—20 μF, 250 V elec. capacitor
C2—0.1 μF, 200 V Mylar capacitor
C3—10 μF, 250 V elec. capacitor
C4—3 μF, 100 V Mylar capacitor
C5—68 μF, 15 V, 10% high-quality tantalum capacitor
C6—0.02 μF, 600 V disc ceramic capacitor
S1—D.p.d.t., 10A center-off toggle sw.
S2,S3—D.p. 10-pos. non-shorting selector sw.
S4,S5—Two-circuit, 5A push-button sw.
S6—S.p.s.t. footswitch
S7—S.p.d.t. 5A footswitch
SO1,SO2—4-prong Jones socket
SO3,SO4—Chassis-mounting a.c. outlet
PL1,PL2,PL3—4-prong Jones plug
F1—1A fuse (for 100 W or less load) 2A fuse (200 W or less load), etc., see text
SR1—18A, 200 V press-fit bridge rectifier, 1N4436 or 4 3A, 200 V silicon diodes (Motorola MR1032B)
GCS1—Gate controlled switch (Motorola MGCS 924-4, 5A @ 200 V) or Texas Inst. TIC-12
D1,D2—750-mA, 200-V silicon power diode
D3—22V, 1W zener diode (Motorola 1N3028B)
Q1—2N1302 transistor
Q2—2N1671 unijunction transistor

into the GCS gate. This turns off the GCS, the timing circuit, and the load.

By switch-selecting *R* in a digital manner, the time interval may be selected. A "units" and a "tens" decade is used to give incremental one-second intervals between one and 100 seconds.

There is a major problem inherent in UJT timers that is eliminated in this upside-down circuit configuration. In a normal UJT, after turn-on and capacitor discharge, there is still a charge remaining on the timing capacitor. This charge slowly bleeds off and ultimately reaches zero after a long time period. The timing error introduced between starting with no charge and starting with some charge is considerable and can approach 40% of the time cycle. To overcome this problem, a set of mechanical contacts is almost always used to reset the UJT and its capacitor to zero charge. While this method is widely used, it is neither convenient nor practical to have to reset a timer mechanically each time cycle.

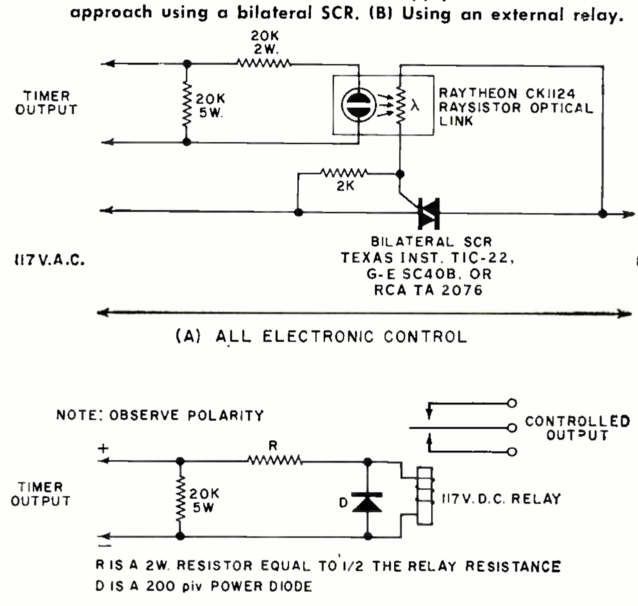
The fact that the supply voltage, but not the supply impedance, disappears at the end of the time cycle is used to automatically reset the timer. This is a function of diode *D* (Fig. 1B). When the −20-volt supply is operative, *D* is reverse biased and does not interfere with the normal time cycle. When the time cycle ends, the supply voltage disappears. Any charge remaining on *C*1 now *forward* biases diode *D*, providing a discharge path through resistors *R*1, *R*2, and *R*3. Note that this is independent of the timing resistor, giving an equal recovery time regardless of the setting of the time interval selectors. The recovery time of the circuit is on the order of a half second to give a repeat accuracy error of less than 2 percent.

By careful selection of *R* resistance values, use of high-quality timing capacitors and zeners, and by waiting only a few seconds between cycles, this timer may be made to have an accuracy of better than 0.5 percent, and perhaps as good as 0.2 percent. This figure includes both repeat accuracy and long-time stability.

Final Circuit Arrangement

Fig. 3 shows the final circuit. The input power may be either conventional power line or d.c. between 100 and 130 volts. Fuse *F*1 is rated slightly above the load power to protect the circuit. Capacitor *C*6 is a filter to reduce AM radio noise during turn-on and turn-off of the time cycle. Switch *S*1

Fig. 4. Additional driver circuits may be added for loads that will not operate on inverted a.c. supply. (A) All-electronic approach using a bilateral SCR. (B) Using an external relay.



is the power switch which also selects between timed and sustained ("on") operation of the devices.

The GCS used is the *Texas Instruments* TIC-12 rated at 5 amperes and 200 volts. (*Editor's Note: As this is written, the TIC-12 costs $9.60.*) It is in a diamond-shaped power transistor package and mounts in the usual manner. Both *SR*1 and the GCS must be mounted on a heatsink, with the GCS insulated from the heatsink.

The network consisting of *C*2, *R*2, and *R*3 provides the GCS positive gate pulse required for turn-on. This is a one-shot network, required to make the time cycle independent of the length of time the "Time-Start" push-button (*S*4) or foot switch (*S*6) is depressed.

The timer power supply consists of *R*5, *R*6, *R*18, *D*1, *D*3, *C*3, and *C*4. Unless GCS1 is conducting, there is no voltage drop across the load and no voltage across this power supply. This is a conventional zener supply except for its negative output. Unijunction transistor *Q*2 provides the time function when its emitter voltage exceeds the value required for breakdown. Timing is provided by a selected interval resistor charging up *C*5. A high-quality capacitor with low leakage must be used here; otherwise leakage and time degradation will affect timer performance.

The obvious way to select a time interval would be to use twenty precision resistors in values of 1, 2, . . .10 and 10, 20, 30 . . . 90, and switch these one at a time to obtain the desired time interval. By adding a second deck to each switch, and using the switching scheme shown in Fig. 3, only eight resistors are required. Note that at least one resistor must always be in the circuit. It is quite important that non-shorting selector switches are used.

The exact value of the resistors is determined by using an oscilloscope whose time base may be used for calibration. The one-second resistor value is then determined experimentally. All the other resistors are precision multiples of this original value. Once the "tens" decade series of resistors have been determined approximately, a conventional electric clock, equipped with a second hand, can be used to accurately trim the resistor values. Set the clock's second hand to 12, plug the clock into the timer output, and select the time values with the "tens" decade switch. Each "tens" decade switch position should cause the clock to indicate the correct number of seconds. The pertinent resistors can be trimmed as required.

The actual resistance may be obtained by several means. The simplest is to use all one-percent resistors. A second alternative is to use one- or two-watt carbon resistors and a file to raise them to the exact value. (Start with a resistor that gives you a time somewhat *shorter* than that desired.) The resistors must be resealed after filing to make them humidity and time stable. A third method is to use a large number of half-watt resistors and keep trying parallel combinations until the exact values are obtained. In all these cut and try methods, an accurate timing device (oscilloscope or other accurate timer) is required.

The final circuitry consists of gating transistor *Q*1 which is used to discharge capacitor *C*5 into the gate of the GCS *via* current-limiting resistor *R*4.

Two two-circuit push-buttons are used to provide the "Time-Start" and momentary bypass controls. Four-prong connectors bring these connections to the rear of the timer, allowing footswitch control. The "Time-Start" footswitch (*S*6) is in parallel with the "Time-Start" push-button (*S*4) while the momentary bypass footswitch (*S*7) is in series with the "Manual-Operate" push-button (*S*5).

Footswitch *S*7 must be a s.p.d.t. switch having heavy enough contacts to handle the load power. A jumper must be substituted for the normally closed connection of this switch if footswitch operation is not to be used. *S*6 is a s.p.s.t. footswitch and need only have a contact rating of half an ampere. This switch must not have a built-in neon pilot light because this type will not allow proper operation of the turn-on pulse network.

Reasonable size wire, at least #20, should be used for all internal connections that must carry the load current.

The timer is intended for use only with loads which will operate off inverted a.c. This includes all incandescent lamps, heaters, and most universal motors (motors with brushes). If a highly inductive load is used, a diode or varistor should be added to the output as a surge eliminator. The timer will not operate a fluorescent lamp directly or the "cold boxes" occasionally found on enlargers. The timer will not directly control an a.c. induction motor of any type.

Additional Drivers

If fluorescent lamp or induction motor operation is required, additional circuitry will be required to provide a switched a.c. output. Two possibilities are shown in Fig. 4. In Fig. 4A, the timer output actuates an optical link ("Raysistor") which in turn gates a bilateral SCR. Loads of between 10 and 600 watts may be switched with the bilateral SCR. The output waveform of this circuit is identical to the input powerline waveform, except for a drop of about one volt. Fig. 4B shows how a conventional mechanical relay may be coupled to the timer and used for special switching requirements. ▲

TV DISC RECORDER

By recording on a high-speed magnetic disc rather than on a length of magnetic tape, short time interval color and monochrome signals may be stored and played back.

THE conventional method for the recording and playback of TV video signals on tape has been with the use of a special tape recorder using a length of tape transported past the rapidly revolving heads. To insure good high-frequency response, the head-to-tape speed has to be very high and even for a still picture, which consists of a large number of redundant frames, a considerable amount of tape is required.

Engineers of the *Sony Corp.* have developed a method that eliminates the bulky reels and awkward threading and setup of conventional video tape recorders with the introduction of their disc color video playback system shown in Fig. 1.

The video disc itself consists of an aluminum ring, approximately 10 inches in diameter, having a magnetic-oxide-coated plastic sheet covering its interior area. When the disc is mounted on its drive mechanism, it can be made to rotate at 1800 rpm. This will produce a head-to-disc speed of approximately 1000 ips.

Three closely adjacent pickup heads are mounted on a cantilever arm and make contact with the disc surface. In this color version, each color signal (red, green, and blue) is individually recorded on a separate track, and a special pulse generator driven by the rotating disc produces the necessary sync signals. By mechanically moving the cantilever arm carrying the three heads towards the disc center in discrete steps, up to 40 different still color pictures may be played back off the disc. Resolution is in excess of 350 lines. The cost of the suitcase-size device is expected to be about $2000.

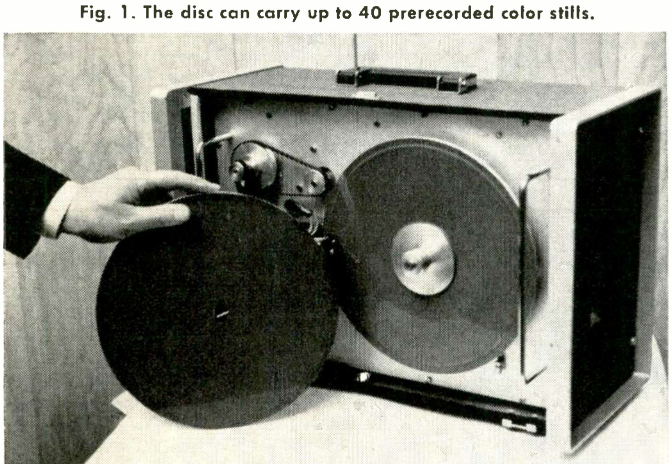
Another version of the disc device, the "Videomat," is built into a 62-inch high, 22-inch wide, 23-inch deep package resembling an automatic soft-drink vending unit.

This version is equipped with a built-in monochrome TV camera and spot lighting system. With the insertion of a coin, or the operation of a remote control, this unit records a 30-second scene on a video disc. The recorded scene is then played back twice on a built-in 19-inch monochrome monitor. A system of front-panel illuminated instruction panels indicates when the machine is in the record or playback mode. The disc is automatically erased after the second playback.

No price has been established for the "Videomat" but production is expected to start in late summer.

No further details, including availability of the disc color playback system, are available at the moment. ▲

Fig. 1. The disc can carry up to 40 prerecorded color stills.



NEW PRODUCTS & LITERATURE

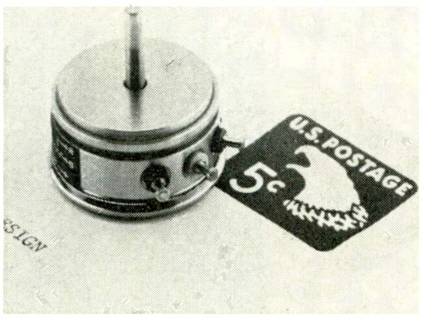
Additional information on the items covered in this section is available from the manufacturers. Each item is identified by a code number. To obtain further details, fill in coupon on the Reader Service Card.

COMPONENTS • TOOLS • TEST EQUIPMENT • HI-FI • AUDIO • CB • HAM • COMMUNICATIONS

SINGLE-TURN POT

A new servo-mounted precision potentiometer that meets the specifications of MIL-R-12934D, style RR1100 is being marketed as the 2550. The 1⅛" diameter potentiometer has a power rating of 1½ watts at 85°C derated to zero at 150°C. It is a wirewound single-turn pot offering ±0.5% independent linearity.

The precision card-wound element is welded directly to the turret lugs to prevent "floating"



when soldering into a circuit. The terminals are gold-plated for easy soldering and corrosion-free shelf life. Color-coded Teflon insulators identify terminal functions and assure humidity-proof performance. Insulated resistance wire prevents all shorting between turns.

The new 2550 pot is available in a resistance range from 10 to 100,000 ohms. Resistance tolerance is as low as ±3%. Resolution runs from 0.338% down to 0.068%. Amphenol Controls

Circle No. 126 on Reader Service Card

COLOR-TV RECTIFIER KIT

In order to handle problems involved in color-TV repair, a new "universal" color-TV rectifier replacement kit has been put on the market. The kit contains one focus rectifier, one booster rectifier, one convergence rectifier, and two power-supply rectifiers. The kit is suitable for making rectifier replacements in color sets manufactured by such firms as Admiral, Emerson, G-E, Magnavox, Motorola, Philco, Zenith. Semitronics

Circle No. 1 on Reader Service Card

DIGITAL PANEL METER

A new digital panel meter, the Model DM-25, offers a simple, inexpensive means of incorporating digital readout into any equipment where accuracy and readability are important.

The "Digimeter" requires less front-panel space than an ordinary 3½" d'Arsonval meter, but is capable of at least 20 to 30 times better accuracy, linearity, and resolution, according to the manufacturer. One model provides direct-reading digital measurement of a.c. or d.c. voltage and current and of temperature, strain, displacement, pressure, or any other parameter for which suitable transducers exist.

Complete electrical and mechanical specifications on the Model DM-25 will be supplied by the manufacturer on request. Abbey Electronics

Circle No. 127 on Reader Service Card

AIR VARIABLE CAPACITORS

Extremely high "Q" and greater capacitance values are featured in the new VAM series of miniature air variable capacitors now available. The small, rugged units have a "Q" factor of greater than 2000, measured at 100 MHz and 10 pF. They offer extremely low losses at higher frequencies. Capacitance range is from 0.8 to 10 pF measured at 1 MHz. They are designed for panel mounting or printed-circuit use. Insulation resistance is 10^6 megohms at 100 volts d.c. and 25°C. Units are gold plated to prevent corrosion damage and for high surface conductivity. A high-density insulator between rotor and stator provides excellent structural strength as well as electrical characteristics. JFD Electronics

Circle No. 128 on Reader Service Card

H.F. TRANSMISSION LINES

A series of dual high-frequency transmission lines, which are designed for such applications as transmission of digital data in computers, are available as complete cable assemblies with connectors. They can also be used in any application where high-frequency transmission and consistent impedance characteristics are considerations. The 93-ohm dual lines have 20 pairs of conductors, terminated in a double row of 0.050" center-distance connectors.

The cable assemblies are constructed of #33 gauge round, silver-plated, copper wire insulated with homogeneous TFE Teflon. The dual-line assemblies are 0.028" thick by 1" wide. Digital Sensors

Circle No. 129 on Reader Service Card

UNWRAP/REWRAP HAND TOOL

A new hand tool, on which a patent is pending, has been developed for removing and replacing coiled wire connections on solderless (wire wrap) type terminals. The unwrap end of the tool slightly loosens the wire coil so that it may be removed intact from the terminal. When located on another terminal the rewrap tool retightens the wire coil to its original four-pound strength or greater. Time involved is seconds and no damage to the coil results.

The tool is made to fit wire sizes #18 AWG or smaller. A data sheet giving complete information on the new tool will be forwarded on request. McCallus Industries

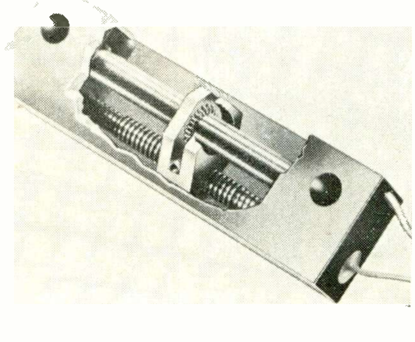
Circle No. 130 on Reader Service Card

WIREWOUND TRIMMING POTS

A new series of rugged trimming potentiometers, tradenamed "Nu-Trim," is on the market. These units are designed with a ring of multiple contacts around the resistance element to provide smooth, light, and even contact pressure in all directions. During adjustment, the unit's spring ring makes many sequential contacts on each turn of resistance wire as the line of contact moves in a spiral motion. As a result of this concept, resolution is increased and the wiper contact noise is less than 20 ohms at vibration levels in excess of 100 G's.

Other features include resolution better than 0.1%, welded lead construction, reliable all-metal clutch, rugged diallyl phthalate glass-filled housing, no exposed metal, 2-watt power rating, and 50 ppm temperature coefficient. Available resistance ranges are from 10 ohms to 100,000 ohms. Newport Instrument

Circle No. 131 on Reader Service Card



SOLDERING-IRON CONTROL UNIT

A compact, 1¾" cube unit has been developed which will convert any soldering iron currently in use into a high-reliability instrument. The new control unit permits a reliable temperature setting from 400° to 1000° at the turn of the dial from position 1 to position 7. The control takes all the guesswork out of determining correct soldering temperature.

The control unit, if plugged into an outlet, still permits full use of the outlet. The right side of the control is a straight-through plug, while the outlet on the left is the controlled plug for the iron. Hunter Tools

Circle No. 2 on Reader Service Card

CERAMIC BANDPASS FILTERS

New miniature low-frequency ceramic bandpass filters, at frequencies from 9 kHz to 50 kHz are now on the market. The filters are suitable for use in either military or commercial applications. Typical characteristics of the filters include 3 dB bandwidth of 1%, a 20 dB/3 dB bandwidth ratio of 13, and a mid-band insertion loss of less than 3 dB. Filters over the entire frequency range are hermetically sealed in HC-6/U crystal cans and weigh a total of less than ¼ ounce.

Impedance characteristics vary with frequency from 56,000 ohms at 10 kHz, 47,000 ohms at 20 kHz, 33,000 ohms at 30 kHz, to 22,000 ohms at 50 kHz. Center frequency of the filter changes less than 0.25% in 5 years and varies less than .3% over the temperature range of −40° to +85°C. Clevite

Circle No. 132 on Reader Service Card

SERVICE-TYPE V.T.V.M.

The Model 905 vacuum-tube voltmeter is a general-purpose unit which is suitable for radio and TV service work, school and home laboratories, production lines, and industrial maintenance applications. The unit is supplied with a fully assembled single a.c./d.c./ohms probe. It features a 0.5-volt d.c. range and also provides peak-to-peak a.c. measurement facilities. Other features include a 200-μA meter electronically protected against overload and burnout, separate scales to indicate true peak-to-peak a.c. voltages, zero-center-scale for FM detector alignment and null detection, precision multiplier resistors with a tolerance of 1%, and an ohmmeter circuit with internal 1½-volt source for all resistance ranges to protect delicate equipment under test. Precise Electronics

Circle No. 3 on Reader Service Card

SHRINKABLE TUBING KIT

A kit containing a complete selection of six-inch lengths of all types of "Fit" heat-shrinkable tubing is now being offered to engineers, lab workers, and designers of prototype models.

Packaged in a compartmented clear plastic box, the kit includes samples of Fit-105 irradiated PVC tubing, Fit-221 irradiated polyolefin tubing, Fit-295 semi-rigid irradiated polyolefin tubing, Fit-300 surface irradiated polyolefin tubing, Fit-350 irradiated high-temperature Kynar tubing, and samples of Fit caps and markers.

The kit comes with an 8-page brochure which gives complete specifications and dimensions of the shrinkable tubing line. Alpha Wire

Circle No. 133 on Reader Service Card

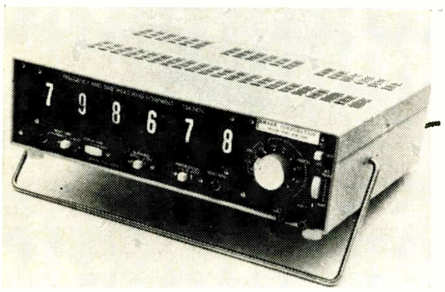
"N"-CHANNEL FET'S

A new series of "n"-channel FET's, the 2N4117, 2N4118, 2N4119, is now available for low-power audio applications. The series offers tight 3-to-1 range of low I_{DSS}, a 2½-to-1 g_{fs} range, low C_{iss}, and 10 picoamp max I_{GSS}. The very low input current and low capacitance (3 pF) make these units suitable for high input impedance a.c. or d.c. amplifiers, storage circuits, choppers, and electrometers. The FET's are packaged in the TO-72 can. Siliconix

Circle No. 4 on Reader Service Card

TIME/FREQUENCY METER/COUNTER

A fully transistorized, compact time/frequency meter/counter is now on the market. Based on a 1 MHz oven-controlled crystal, the instrument offers three gating times: 0.1 sec, 1 sec, and 10 secs, providing a frequency measuring range



from d.c. to 1.2 MHz. Accuracy is ±1 count + crystal stability of 1 part in one million. The period measurement with its three gating times of 1, 10, and 100 cycles allows measurements from d.c. to 100 kHz. A six-place digital in-line readout is legible from any angle. Full details on the instrument are available on request. Amark

Circle No. 134 on Reader Service Card

PREFABRICATED HEAD ENDS

A new concept of factory fabricated head ends designed to increase the sales of master antenna television equipment has been announced. The prefabricated head end is designed to add sales appeal to MATV systems and to make it possible for the installer/distributor to install home systems with minimum expenditure of manpower. The head end is tested and aligned for specified channels and delivered to the distributor ready for installation. No costly labor is necessary to assemble component parts. The head end is installed, the distribution cables are hooked to the output, the antenna cables are connected to the input, and the system becomes operative. Blonder-Tongue

Circle No. 5 on Reader Service Card

SILICON RECTIFIER KIT

A practical solution to the problem of stocking rectifiers for prototyping is offered by the new rectifier kit now available. The kit is designed to provide the engineer and lab technician with a convenient stock of rectifiers and molded rectifier bridges, eliminating costly delays for ordering needed, but out-of-stock, components.

A total of 13 premium silicon rectifier types and 8 types of molded full-wave rectifier bridges is included in the kit to meet a wide variety of rectification requirements. Rectifier current ratings range from 0.25 to 35 amperes with voltage ratings from 200 to 3000 volts. All of the rectifiers and full-wave bridges included in the kit are standard items in the company's distributor line. Motorola

Circle No. 135 on Reader Service Card

22-AMP SCR LINE

A 22-ampere series of silicon controlled rectifiers with p.r.v. ratings from 25 to 700 volts (800-volt non-repetitive transient rated) is now available. The series has a maximum current rating of 22.3 amps average (35 amps r.m.s.) at up to 70°C case temperature and a junction temperature capability of 150°C. The maximum operating temperature of 150°C permits significant current ratings in higher ambient temperatures than with conventional 125°C maximum devices of identical physical size.

Further information on this new series is included in Bulletin A-117 which will be forwarded upon request. International Rectifier

Circle No. 136 on Reader Service Card

MOLDED MICA CAPACITORS

A new line of molded mica capacitors, designated HTCM, has been developed for applications requiring reliable operation at the higher operating temperatures. According to the company, the new units have approximately the same low failure rate as dipped mica capacitors and are obtainable for operation at 125°C and 150°C per the requirements of MIL-C-5.

At present, the line includes case size 15 but will soon include case sizes 20, 30, and 35. Electro Motive Mfg.

Circle No. 137 on Reader Service Card

ADJUSTABLE AND TAPPED RESISTORS

Two new commercial resistor styles—adjustable and tapped power wirewounds—are now in production as the HLA (adjustable) series and the HLT (tapped) series. The new models have the added precision and load-life stability made possible by a multilayer silicone coating. They are direct replacements for vitreous enamel tapped and adjustable types.

All models in both series are wound on hollow, tubular ceramic cores and are of the type used in voltage dividing applications. Made according to MIL-R-19365C, the HLA series includes 12 models with power ratings from 12 to 225 watts and a resistance range from 1 ohm to 100,000 ohms. The HLT series includes 13 models in sizes ranging from 11 to 225 watts with a resistance range from 1 ohm to 1.1 megohms. Dale

Circle No. 138 on Reader Service Card

FIXED PAD ATTENUATORS

A new line of low-cost fixed pad attenuators for pulse, video, and r.f. applications is now available. Fully enclosed, ruggedized metal construction provides shielding and protects the low noise, 1% tolerance resistors used in the attenuation networks.

Attenuators are available in any desired dB value from 1 through 60 dB in 1 dB steps. Standard impedances are 50, 75, and 93 ohms. Standard connectors are u.h.f., N, and BNC. The u.h.f. and BNC attenuators are rated at ½ watt while the type N is rated at 1 watt. Holland Electronics

Circle No. 139 on Reader Service Card

MINIATURE PANEL INSTRUMENT

The Model 120-G has been added to the G-Series panel instrument line and features a "bar-ring" d.c. movement which provides exact, reliable readings and is inherently self-shielded from stray magnetic fields. A special flat insert for the masked portion of the meter front may be painted any color the customer desires and can be imprinted with company logos, instructions, or names for personalizing the meter.

The Model 120-G measures only 1¾" square and extends 1½" behind the panel. A special short-barrel model is available on special order. Instrument movements range from 10 μA d.c. up. Triplett

Circle No. 6 on Reader Service Card

THERMAL SWITCH

A new thermal switch, Series 4300, is now available as a snap-acting, heavy-duty bimetal actuated unit. Contacts are single-pole, single-throw, available either normally open or normally closed and are capable to switching up to a 30 amp resistive load or a 1500 watt tungsten load.

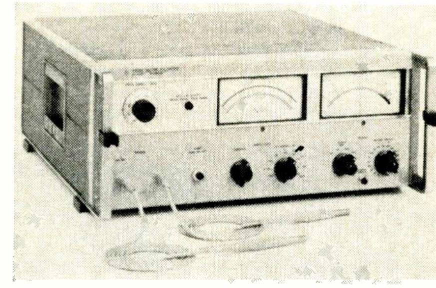
Units are available with delay times ranging from 5 seconds to 4 minutes and, because of its thermal action, the switch will integrate pulses or intermittent current to eliminate short cycling or chatter. Hart Mfg.

Circle No. 140 on Reader Service Card

VECTOR VOLTMETER

The new vector voltmeter, Model 8405A, is a dual-channel, wideband r.f. millivoltmeter and phase meter. It has a frequency range of 1 MHz to 1 GHz, a maximum sensitivity of 100 microvolts full scale, and ±180-degree phase measurement range with resolution to 0.1 degree.

The unit reads voltage directly with one of two pencil-size high-impedance probes. With a second, elsewhere in the circuit under measurement, it reads phase angle relative to the first



probe. The second probe and its meter may be switched to read voltage, giving direct and simultaneous reading of gain between points.

The 8405A automatically tunes when a single knob is set anywhere within an octave of the signal frequency being measured. The instrument finds and phase-locks to the fundamental signal at the first of the two probes in 10 milliseconds. Hewlett-Packard

Circle No. 141 on Reader Service Card

LOW-NOISE R.F. AMPLIFIER

A MOSFET low-noise r.f. amplifier, which offers low cross-modulation distortion, is being marketed as the FT57. The unit is an "n"-channel depletion model MOSFET which offers the high stability and reliability of the firm's patented "Planar II" epitaxial process, features a low noise figure, low reverse capacity, and high power gain, making it suitable for use in FM and v.h.f. television applications.

The FT57 is available in a four-lead TO-72 package. Fairchild Semiconductor

Circle No. 142 on Reader Service Card

KITS FOR V.S.W.R. MEASUREMENTS

A series of complete, pre-packaged kits for making v.s.w.r. measurements has been introduced. Utilizing a "Rho-Tector" v.s.w.r. detector, the kits contain everything necessary for making the impedance comparisons basic to v.s.w.r. measurements in r.f. and microwave devices.

Besides the detector, which comes in any one of five models operating in a frequency range from 1 MHz to 4 GHz, each kit contains two standard matched terminations and two mismatches. All five items are packed in a fitted wooden instrument case. Telonic

Circle No. 143 on Reader Service Card

INSTRUMENTATION COOLING FANS

Designed for cooling low-profile instrumentation and measuring only 3⅛ inches square, the new "Sprite" fan delivers 35 cubic feet of air per minute at free delivery.

The new fan was designed for general-purpose cooling and ventilation applications where small size and low cost are important requirements. The fan is recommended for applications requiring pressures of .05 inch of water to 0.75 inch of water at 25 to 3 cubic feet per minute. A double-flange construction provides universal mounting. Rotron

Circle No. 7 on Reader Service Card

METALLIZED-POLYCARBONATE CAPACITOR

A metal cased miniature metallized-polycarbonate capacitor designed to meet the requirements of miniaturized production has been released as the K323Z.

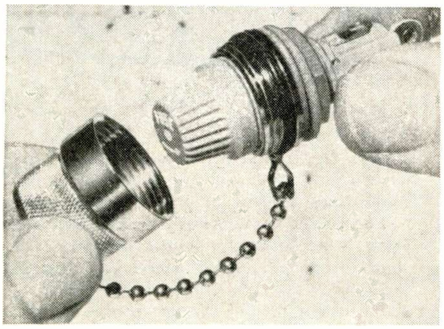
Featuring excellent stability at higher voltages, the metallized-polycarbonate film used as the dielectric in this new unit provides maximum stability, low dissipation factor, low dielectric absorption, and high insulation resistance. The capacitors have a standard tolerance of ±20%. Units with ±10%, ±5%, and lower can be supplied. Voltage ratings are 100, 200, 300, 400, and 600 volts d.c. with capacities from 0.01 μF to 5 μF. Aerovox

Circle No. 144 on Reader Service Card

FUSE EXTRACTOR POSTS

Two new waterproof r.f. shielded fuse extractor posts that eliminate possible transmission or reception of stray r.f. signals through the hole in the chassis used for the fuse post mounting are now available.

They are designed to take 3AG and 8AG size fuses and for use in such applications as military ground support test equipment and commercial and industrial computers. The shielded fuse ex-



tractor post for the 3AG fuses (1¼" x ¼" diameter) is Part #340225 while for the 8AG fuses (1" x ¼") the part is #370011. They are ruggedly constructed to withstand environmental conditions such as salt spray, vibration, shock, and water immersion. Littelfuse

Circle No. 145 on Reader Service Card

DESOLDERING KIT

A nine-piece desoldering kit which comes in a handy steel storage box is now being marketed as the Model 300-K. The kit contains a Model 300 pencil-style desoldering iron, six tips of different sizes from 0.038 to 0.090, a metal stand for the iron, and a tip cleaning tool. Included is a new 0.063 industrial-type tip with premium alloy. The iron is used to remove defective soldered components and to resolder replacements. The box for the kit is 10" x 3¼" x 1¾" and has a rugged hammertone finish. Enterprise Development

Circle No. 8 on Reader Service Card

HI-FI—AUDIO PRODUCTS

RIGHT-ANGLE AUDIO PLUG

A unique right-angle, 8-position plug which eliminates cable entry and routing problems in compact electronic equipment is now on the market. The miniature plug is adjustable so that cabling can be routed through the integral rubber strain relief in any of eight directions. Entry routes are spaced every 45° in a circle on a plane parallel with the panel or chassis-mounting position of the plug. Only ⅜" movement along the axis of the plug is required to connect or disconnect and less than 1½" total distance is needed to mount the plug (this includes length of plug and connect-disconnect travel). Full engineering specifications on this and other plugs and receptacles in the company's line will be supplied on request. Switchcraft/Preh

Circle No. 9 on Reader Service Card

80-WATT STEREO AMPLIFIER

The LRE-80 solid-state stereo amplifier utilizes 29 semiconductors and features instant operation, without hum, noise, or microphonics and sufficient power to drive any stereo speaker to its full capacity.

Controls and inputs include: bass, treble, dual volume, 5-position mode, 5-position input, 4-position output including power/off, speaker phase, and headphone switch. There are rocker switches for low filter, high filter, loudness, tape monitor, and a special stereo headphone jack for tape head or phono input. There are also stereo inputs for tuner, tape recorder and aux. #1 and aux. #2. There are two convenience outlets, one switched.

Power output is 80 watts IHF (40 watts per channel) and response is 22-24,000 Hz ± 1 dB. The unit has an extruded aluminum, gold-finished panel and measures 13³⁄₁₆" wide x 4½" high x 10½" deep. It is designed to operate on 110-120 volts, 60-cycle a.c. Lafayette

Circle No. 10 on Reader Service Card

DYNAMIC MICROPHONE LINE

A new line of dynamic microphones, offered in a choice of impedances and designed for use with transistorized solid-state and tube equipment, is now on the market. Impedance range is 200, 600, 10,000, and 50,000 ohms. Diaphragms are made of rugged polyester film and can withstand high temperature and humidity conditions. A unique method of encasing the cartridge cups in rubber sleeves offers the user a shock-resistant mike and helps cut to a minimum handling and clothing noises.

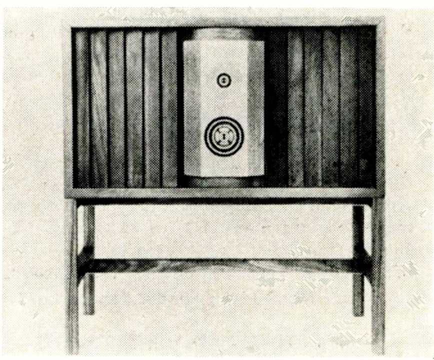
The microphones are made of die-cast metal and finished in brushed chrome. Seven basic models are currently available and the manufacturer will supply full specifications on this new line upon request. Sonotone

Circle No. 11 on Reader Service Card

CABINET SPEAKER SYSTEM

A new convertible speaker, the "Grenadier" 8400, features louvered front panels and a hand-rubbed satin walnut finish. It is designed for standard shelf placement or on its own custom-made walnut bench.

Additional features include a low-frequency hyperbolic horn; a mid-range direct radiator, and ultrasonic domed tweeter, both coupled to die-cast acoustic lenses; frequency response of



25 to 20,000 Hz; nominal impedance of 8 ohms; and power handling capacity of 100 watts maximum undistorted. Empire Scientific

Circle No. 12 on Reader Service Card

P.A. AMPLIFIER

The new model "Twenty Three" amplifier incorporates many built-in features for a more effective background music/paging system or portable p.a. applications. There are three microphone inputs with separate gain controls; phono input and auxiliary input for tuner, tape recorder preamp, or radio output; 70-volt line output; and convenience a.c. outlet.

A paging switch automatically mutes other microphone, phono, and auxiliary inputs. A five-step tone control and master power switch are also provided. The amplifier has a full 20 watts power output and a frequency response of 20 to 20,000 Hz ± 2 dB. Bell

Circle No. 13 on Reader Service Card

AM-FM STEREO RECEIVER

The all-transistor "Stratophonic B" Model SR-400B is an AM-FM stereo receiver with 60 watts IHF music power output. A precision styled front panel includes a new two-system speaker selector, improved d'Arsonval tuning meter, headphone jack, positive-action multiplex indicator, and new rocker switches for tape monitor and contour.

Performance features include a 2.9 μV front end, 6 to 50,000 Hz bandwidth, frequency response of 5-60,000 Hz at normal listening levels and 8-40,000 Hz at full 60 watts. Harman-Kardon

Circle No. 14 on Reader Service Card

COMPACT RECORD PLAYER

A four-speed manual player, designated the Model SP20, has recently been put on the

market. Incorporating many high-fidelity features including a semi-counterbalanced arm with adjustable stylus pressure, a trip built of DuPont "Delrin" which will allow the unit to track as light as 2 grams, a full-sized weighted turntable, and interchangeable plug-in head which will accommodate any cartridge, the unit measures 14⅜" left to right, 12½" front to rear, and 3½" above and 2⅛" below the motorboard. Garrard

Circle No. 15 on Reader Service Card

HEADSET-MICROPHONE ASSEMBLIES

By using standard components and subassemblies in a new series of lightweight headset-microphone assemblies, a broad line of essentially custom-made headsets to meet varying communications problems is available.

The headsets are designed to offer maximum comfort. Circumaural earcups surround the ear instead of pressing against it. Soft, vinyl-covered, foam-filled earcushions form an acoustical seal against the head without excessive pressure. Materials and construction meet military and telephone standards of quality.

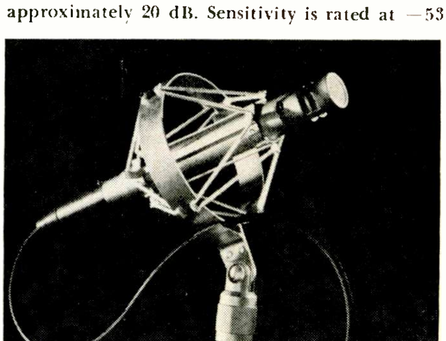
The miniature dynamic earphone elements are supplied in impedances of 20, 150, and 300 ohms. Sensitivity is 105 dB at 1000 Hz re: 0 dB 0.0002 dyne/cm² with input of 1 mW. Frequency range is 100 to 4500 Hz with harmonic distortion less than 2% with 1 mW applied. Roanwell

Circle No. 16 on Reader Service Card

CAPACITOR MICROPHONE

A new pressure gradient type capacitor microphone, the S-10, which operates on a single TR-126 mercury battery and employs a field-effect transistor, has been announced. Permanent polarization is supplied at 62 volts and the Mylar diaphragm gives the unit excellent response.

Frequency range is 40 to 20,000 Hz with a deviation of less than 3 dB. The cardioid pattern gives effective front-to-back discrimination of approximately 20 dB. Sensitivity is rated at −53



dBm re: 10 dyne/cm² at 200-ohm load. The XLR-type 4-pin connector serves as an "on-off" switch, eliminating unnecessary battery drain.
The microphone has a satin nickel finish and measures 7⅜" long. Diameter is ⅞" and the unit weighs only 9 ounces with battery. The S-10 comes with 20 feet of cable, swivel mount, battery, and carrying case. Syncron Corp.

Circle No. 17 on Reader Service Card

SOLID-STATE STEREO AMP

A solid-state stereo amplifier which provides 30 watts music power (IHF) output per channel at 4, 8, and 16 ohms impedance has been put on the market as the Model "Sixty." Frequency response is 10 to 100,000 Hz ±2 dB; stereo separation at 1 kHz is 65 dB; and THD is 0.5% at rated power. The treble tone control provides 10 dB boost and 15 dB cut at 10 kHz while the bass control offers 15 dB boost and cut at 50 Hz.
The unit measures 15¼" wide x 3¼" high x 8½" deep, including knobs, dress panel, and

fuses. An optional walnut cabinet is available at additional cost. Audio Dynamics

Circle No. 18 on Reader Service Card

PROFESSIONAL RECORDER

A new line of solid-state professional audio recorder/reproducers for studio use by recording companies and radio stations has been introduced as the Series AG-300.
In addition to solid-state electronics for greater reliability and performance, the new AG-300 offers an improved tape transport and console design improvements featuring modern functional styling and simulated walnut side panels.
The console has overhead electronics and a transport that can be tilted to various operating angles for user convenience. The transport may be turned over for servicing without dismounting. Other new electronic features include tweaking adjustments on the front panel, plug-in equalizers for maximum flexibility, new locking-type level set knobs, and new "ready to record" light to permit visual confirmation of proper settings from remote locations.
The series includes one-, two-, three-, and four-channel models, either mounted or unmounted. Speeds are 15 and 7½ ips. with frequency response ±2 dB from 30 to 18,000 Hz at 15 ips. Ampex

Circle No. 146 on Reader Service Card

CB-HAM-COMMUNICATIONS

PRINTED-CIRCUIT CB TRANSCEIVER

The new Model 650 is an 18-transistor, 9-diode CB transceiver which contains a crystal correlated tunable receiver, adding the stability of a crystal-oscillator to a high-"Q" tuned circuit. Seven panel controls plus an easily read output/"S" meter permit a high degree of regulation and monitoring of transmitted and received signal. A switch mounted on the squelch control converts the 650 to a p.a. system when used with an external speaker.
The dual-conversion superhet receiver in the Model 650 uses a crystal-controlled first oscillator and a tuned second oscillator. The first i.f. is 4.3 MHz and the second is 455 kHz, offering a high conversion frequency and hence freedom from images.
The unit has a 10-channel crystal switch for selecting transmitting and receiving frequencies when the transceiver is completely crystal controlled and for selecting the transmitting frequency alone when the tuner is used. It comes factory equipped with channel 11 crystals.
With self-contained 12-volt d.c. and 117-volt a.c. power supplies, the unit measures only 3¾" high x 6¾" wide x 9½" deep. Amphenol

Circle No. 19 on Reader Service Card

12-CHANNEL CB TRANSCEIVER

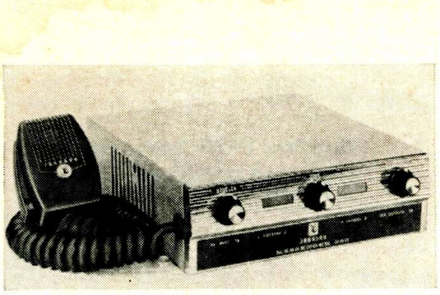
The Model 712 "Sentinel 12" is a 12-channel, dual-conversion, 5-watt CB transceiver which provides twelve crystal-controlled transmit and receive channels and complete tunable reception of all 23 CB channels. It features adjustable squelch and noise limiter and switches for 3.5-

watt p.a. use, spotting, and Part 15 operation. The integral transistorized dual power supply operates from 12-volt d.c. or 117-volt a.c.
The unit comes with a channel 9 transmit crystal, mobile mounting brackets, a.c. and d.c. power cords, noise canceling push-to-talk ceramic microphone and measures 4¾" x 12" x 7½". It is available only in wired form. Eico

Circle No. 20 on Reader Service Card

SSB CITIZENS BAND UNIT

The greater performance of single sideband has been made available to users of CB equipment with the introduction of the "350."
The SSB mode of transmission furnishes up to 30% greater range over ordinary 5-watt AM Citizens Band transmitters when operating conditions are ideal. Under actual use during periods of high noise, severe skip interference, and other atmospheric interference, the new unit can deliver up to three times the range of other CB units.



The "350" can operate on any of 46 different frequencies without adjacent channel interference. The unit is all-solid-state. Mechanical relays have been eliminated by a diode switching system, yielding complete reliability.

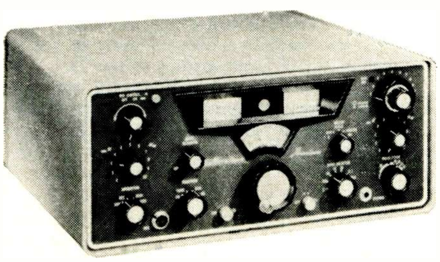
The unit weighs 6 pounds for 12-volt operation and comes in a cabinet 8" wide x 2½" high x 9½" long. An optional a.c. power supply for base-station use is available. E. F. Johnson

Circle No. 21 on Reader Service Card

FIVE-BAND TRANSCEIVER

A new 80, 40, 20, 15, 10 meter transceiver has been introduced as the SR-2000. Transmitter power input is 2000 watts p.e.p. on SSB and 1000 watts on c.w. Despite the high power, the unit measures only 7½" high x 16½" wide x 15" deep.

The transmit section has two 8122 output tubes and a variable pi network. Carrier and unwanted sideband suppression is rated at 50 dB and distortion products are 30 dB. The audio



output is measured at 500 to 2600 Hz at 6 dB. Cooling of the section is handled by a two-speed blower.

Sensitivity of the receive section is less than 1 μV for a 20 dB signal-to-noise ratio. The audio output for driving a speaker is 2 watts and overall gain is 1 μV for ½-watt output. The receiver first i.f. is 6.0-6.5 and the second i.f. is 1650 kHz. Hallicrafters

Circle No. 22 on Reader Service Card

25-CHANNEL TRANSCEIVER

A 25-channel CB transceiver which provides coverage of the 23 CB channels plus two emergency "H.E.L.P." channels has been introduced as the Stock No. 99-3064WX.

The unit is a dual-conversion transceiver; has a full-wave range-boost circuit; uses 13 tubes, 2 transistors, and 9 diodes; offers 0.3-μV sensitivity and adjacent channel rejection. Receiver selectivity is 8 kHz at 31 dB down. Other features include a combination "S" and power output meter; 100 mW and 5-watt power input switch; variable ANL and squelch; p.a. switch with front-panel volume control; and built-in 117-volt a.c. and transistorized 12-volt d.c. power supply.

The unit measures 12" wide x 5" high x 8⅝" deep. It comes complete with mobile mounting bracket, cables, and ceramic push-to-talk microphone. Lafayette

Circle No. 23 on Reader Service Card

MANUFACTURERS' LITERATURE

DIGITAL READOUTS

A new and enlarged 1966 catalogue listing a full line of incandescent lamps and digital readouts is now available. Featured in the booklet are "Midgi-Lite" digital readout heads; "Midgi-Mate" miniature drivers and encoders with rugged epoxy encapsulation and brightness adjustability; and the multi-filament "Alpha-Lite," an alpha-numeric microminiature readout display with variable brightness, modular plug-in construction, and a life expectancy exceeding 50,000 hours. Pinlites

Circle No. 147 on Reader Service Card

ELECTRONIC COMPONENTS

A full line of precision electronic components, including batteries, capacitors, resistors, semiconductors, switches, and controls, is offered in a new 1966 44-page illustrated general catalogue. Mallory

Circle No. 24 on Reader Service Card

PROXIMITY SWITCHES

A new 16-page illustrated catalogue (85d) covering proximity switch systems has been issued. All-metals sensitive systems, which respond to all electroconductive metals, and ferromagnetic-metals sensitive systems, responding to ferrous metals only, are described in detail.

In addition, the booklet supplies mounting dimensions, application data, and a listing of accessories. Micro Switch

Circle No. 148 on Reader Service Card

SEMICONDUCTOR CATALOGUE

Semiconductors, metal-film resistors, wire and cable products, and precision connectors are among the products listed in a new 60-page, short-form catalogue.

Convenient cross-reference information, selection charts, and outline drawings are included. Transitron

Circle No. 149 on Reader Service Card

FILTER NETWORKS

Data useful in specifying custom electronic filters is contained in a new 6-page brochure. Response curves, specification tables, and block diagrams are included, as well as a number of typical filter-network installations. Triad Transformer

Circle No. 150 on Reader Service Card

RADIO INTERFERENCE

A special 18-page report dealing with all phases of radio interference related to the operation of engine generators has been published. Entitled "Radio Frequency Interference," the study discusses causes of r.f. interference and methods of locating, measuring, and suppressing it.

Multi-colored charts outline radio suppression classifications and control limits issued by the Army, Navy, and Air Force. Onan

Circle No. 151 on Reader Service Card

TAPE RECORDERS

Two new, fully transistorized tape recorders for commercial applications are presented in a 6-page illustrated folder.

Model 1021 is a monaural recorder with tape speeds of 3¾ ips for AM broadcasts and 7½ ips for FM. Model 1022 is a stereophonic recorder that operates at 15 ips with wide flat frequency response, good signal-to-noise ratio, and low distortion that are ideal for cutting master tapes. Model 1022 also operates at 7½ ips for general recording requirements. Magnecord

Circle No. 25 on Reader Service Card

TUBE RATINGS

A new mobile communications tube reference guide which contains the basic specifications and "Push-To-Talk-Service (PTTS) ratings for eleven popular tubes is now available.

The PTTS rating system, developed by the company for its own tubes, is based on an operating cycle of 1 minute on (maximum) and 4 minutes off (minimum). This cycle also permits continuous operation for extended periods to allow circuit alignment and tune-up. Amperex

Circle No. 26 on Reader Service Car

INDICATOR LIGHTS

A new 12-page illustrated catalogue (L-178A) describing a complete line of two-terminal, fully insulated, subminiature indicator lights has been issued.

Both incandescent and neon types are offered in a wide choice of lens-cap shapes, finishes, and colors with hot-stamped or engraved legends. Dialight

Circle No. 152 on Reader Service Card

LEVER SWITCHES

A new 4-page engineering specification catalogue (No. S-309) covering four series of new lever-type switches has been issued. Fully illustrated, the bulletin supplies complete mounting information and operating details. A wide selection of colors, knob shapes, illumination, and application tips is offered. Switchcraft

Circle No. 153 on Reader Service Card

PRECISION POTENTIOMETERS

A complete line of microminiature and subminiature, ganging, sine-cosine, high-resolution, sleeve and ball-bearing, linear and non-linear, and fully enclosed, precision-ganging potentiometers is presented in a new 24-page illustrated catalogue. Samarius

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PRODUCT BROCHURE

Illustrations and descriptions of a wide variety of "Scotch" electrical products for the communications industry are provided in a new 8-page booklet. Included are electrical tapes, connectors, splicing kits, sealers, flat cable systems, and mounting plates and cable clips. 3M

Circle No. 155 on Reader Service Card

Home TV Via Satellite

(*Continued from page* 41)

transporting information to other world centers or to developing nations.

To sum up, we at *Arthur D. Little, Inc.* believe that:

- Non-synchronous satellites would require trackers at each home. Large-scale CATV operators could conceivably develop a receiving system to track multiple satellites, but this would be an expensive undertaking.
- Synchronous satellites broadcasting twelve channels to the home are not technically feasible below 200 MHz and are only marginally feasible at 600 MHz. Here expensive receiving equipment is required.
- At frequencies between 2000 and 7000 MHz, trunking is possible but this would require expensive ground equipment that only the most affluent CATV systems could afford.
- A feasible system would require at least a 20,000-watt continuous power source (more probably 30,000 to 40,000 watts of prime power would be required) and the development of high-power transmitting equipment that could operate reliably for many years. Neither development appears possible for many, many years. ▲

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TRANSISTORIZED Products Importers catalog. $1.00. Intercontinental. CPO 1717, Tokyo, Japan.

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Amps	100 PIV	200 PIV	400 PIV	600 PIV
.75*	.07	.10	.14	.21
3	.14	.22	.28	.40
15	—	.75	1.20	1.55
35	—	1.30	2.00	2.70

Amps	700 PIV	800 PIV	900 PIV	1000 PIV
.75*	.25	.32	.40	.55
3	.49	.58	.67	.78
15	1.70	1.85	2.25	2.50
35	3.15	3.60	4.50	4.80

1100 PIV 70c. 1200 PIV 85c. .75 amp
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100	—	.70	1.20	500	1.95	3.00	3.30
200	.80	1.15	1.70	600	2.30	3.20	3.90

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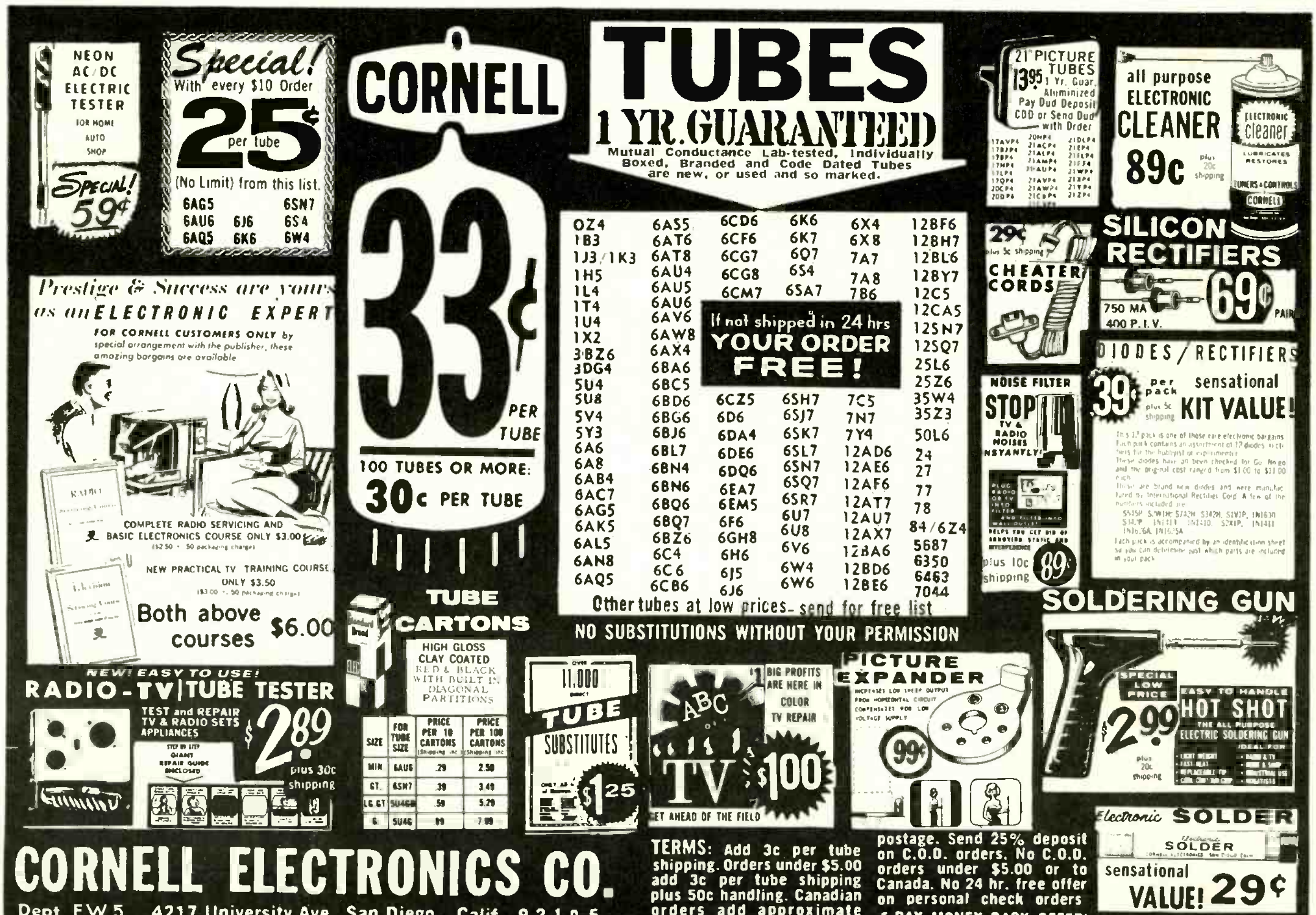

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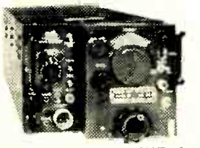

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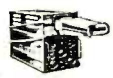

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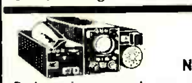

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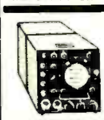

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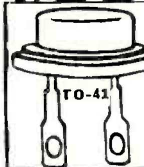

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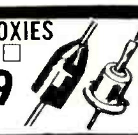

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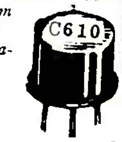

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TRIPLETT ELECTRICAL INSTRUMENT COMPANY, BLUFFTON, OHIO

RANGES

DC Volts:	0-2.5-10-50-250-1,000-5,000 at 20,000 ohms/volt. 0-0.25 at 100 microamperes.
AC Volts:	0-3-10-50-250-1,000-5,000 at 5,000 ohms/volt.
Decibels:	−20 to +11, +21, +35, +49, +61, +75; "0" DB at 1 MW on 600 ohm line.
DC Microamperes:	0-100 at 250 Mv.
DC Milliamperes:	0-10-100-1,000 at 250 Mv.
DC Amperes:	0-10 at 250 Mv.
Ohms:	0-1,000-10,000 (4.4-44 at center scale).
Megohms:	0-1-100 (4,400-440,000 at center scale).

Output Volts (AC): 0-3-10-50-250-1,000 at 5,000 ohms/volt; jack with condenser in series with AC ranges.

CARRYING CASE
Model 639-OS black leather carrying case, built-in stand, Flaps open to permit use of tester in the case. Suggested U.S.A. User Net............................$13.00

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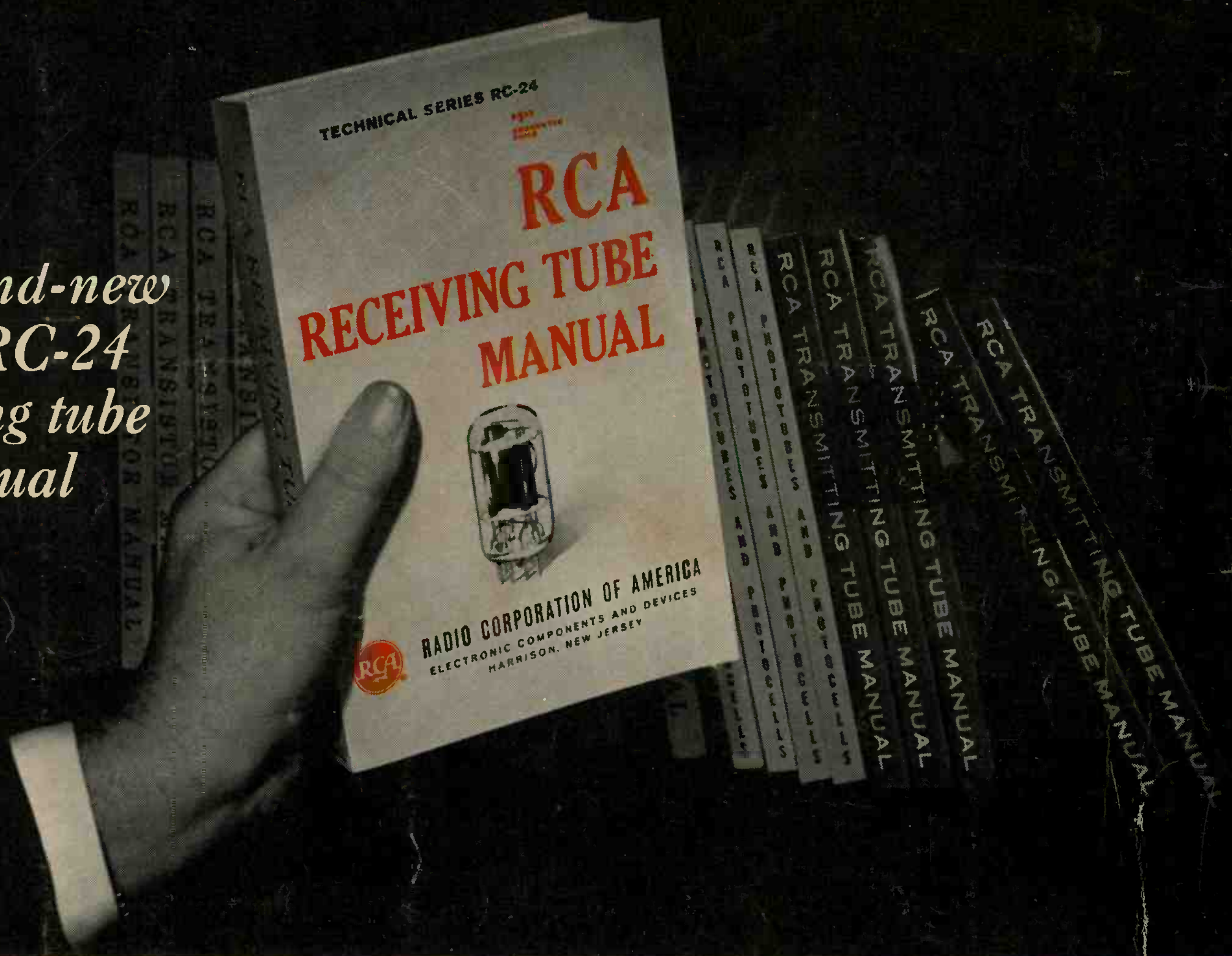

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