Price 35 Cents Feb. '51

FM-TV RADIO COMMUNICATION

★ ★ Edited by ★ ★
Milton B. Sleeper

St. Paul Radio System

ALSO FEATURED IN THIS ISSUE

Mid-Valley Pipe Line Relay
FTB Air-Raid Alert Alarm
FAS Audio System, Part 4

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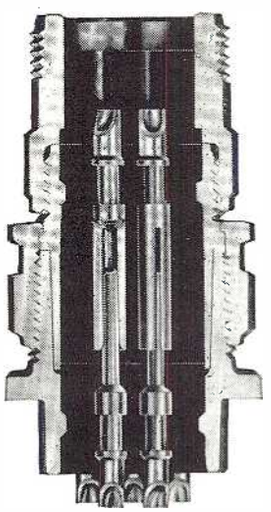

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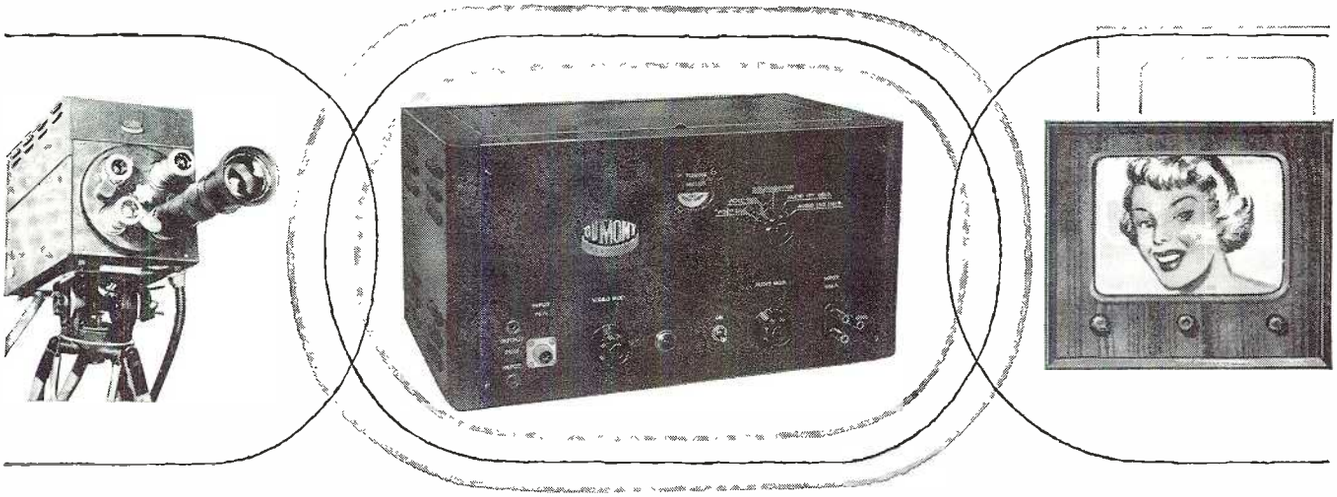
the **magic link**
for closed circuit tv



Camera Signal *The Dumitter* *Standard TV Receiver*

the **dumitter**

Actually a miniature closed-circuit television transmitter. Takes signal directly from any standard camera chain, modulates a carrier frequency of either Channel 2 or 3, and feeds via cable directly through the antenna posts of standard TV receivers. Receivers operate exactly as though tuned to a telecast on that Channel.

Performance superior to other forms of transmission. Audio and video reception absolutely free from outside interference. Truly, the MAGIC LINK for closed-circuit television.

Ideal for use in industrial television applications, for field demonstrations of TV receivers, for studio use, for sales meetings, and countless other uses. Does away with expensive, bulky equipment and circuitry modification of receivers.

- Feeds up to 125 standard TV receivers.
- Distributes signals on standard TV Channel 2 or 3 via cable through regular antenna posts of receivers. No modification of receivers necessary. Receivers may be switched to regular telecast reception at any time.
- Feeds receivers both video and audio through single coaxial cable up to several thousand feet.
- No terminal equalization necessary as attenuation is only at carrier frequency.
- Uses signal from any standard camera chain without interim equipment.
- Completely stable — requires no operator.
- Light, compact, completely stable.
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DUMONT

First with the Finest in Television

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a fine PROFIT for you...in

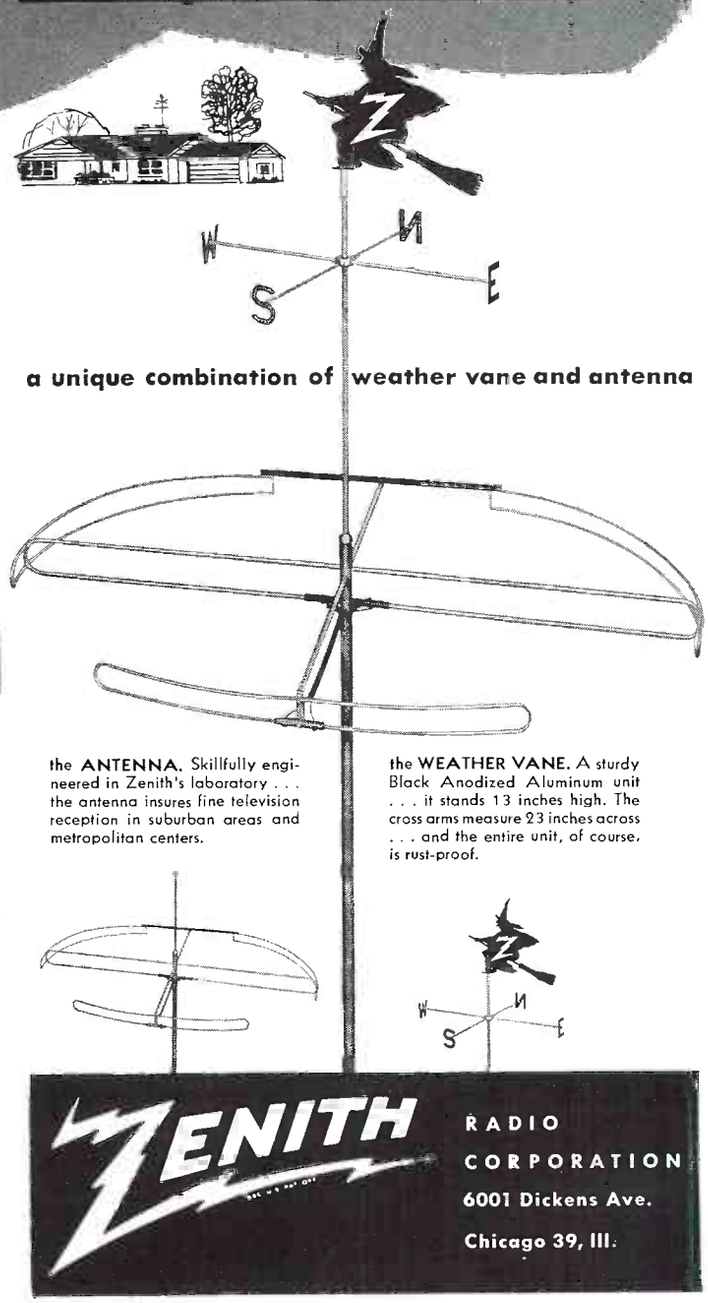
Zenith's spectacular new

Hollywood Antenna Vane

ZENITH DOES IT AGAIN . . . with the Hollywood Antenna Vane that outmodes unsightly antenna installations. Yes, here's really a BRAND NEW item that's both artistic and efficient . . . and that's bound-to-SELL . . . for it reflects one's pride of ownership in his home.

STRIKINGLY NEW . . . GENUINELY UNIQUE . . . there's a large and immediate market for the Hollywood Antenna Vane, for present TV home owners everywhere will want it. AND TV prospects will ask you about this decorative installation every time! Stock it . . . PROMOTE it . . . and you'll realize a mighty handsome PROFIT from carrying it!

The Weather Vane unit is topped by a legendary witch of storybook fame and "rides high" over the inconspicuous IN-Line Antenna which fits parallel to the chimney top or roof. The antenna functions efficiently on both high and low television bands.



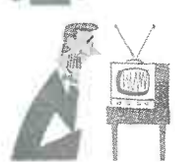
a unique combination of weather vane and antenna

Your sales will come from these 4 groups...

1 TV purchaser who is sales-receptive to a new and beautiful antenna and can be "stepped up" on the difference on installation cost.

2 TV Owner who prides himself on the appearance and beauty of his home.

3 TV Owner who would like to replace the unsightly antenna installation that mars his home.



4 TV Owner who would otherwise prefer "poor reception" to having an "unsightly" outside antenna.

the **ANTENNA.** Skillfully engineered in Zenith's laboratory . . . the antenna insures fine television reception in suburban areas and metropolitan centers.

the **WEATHER VANE.** A sturdy Black Anodized Aluminum unit . . . it stands 13 inches high. The cross arms measure 23 inches across . . . and the entire unit, of course, is rust-proof.

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RADIO CORPORATION

6001 Dickens Ave.

Chicago 39, Ill.

FM-TV RADIO COMMUNICATION

Formerly *FM* MAGAZINE, and *FM* RADIO-ELECTRONICS

VOL. 11 FEBRUARY, 1951 NO. 2

CONTENTS

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IN the past, set production figures shown in this column were for RTMA member-companies only. Effective with November 1950 figures, RTMA revised their former practice to include estimated production of non-members. The Association's method of checking non-member estimates is very accurate, so that the new, industry-wide figures can be considered virtually exact.

In just one respect, they are not complete. RTMA does not show FM tuner production, now running somewhat above 10,000 per month. Consequently, in making estimates of FM homes, it must be borne in mind that the FM figures are for complete sets only, and will be short by about 100,000 of the actual FM receivers installed in 1950.

We have no way of knowing how much extra TV production was added in the November figures by the inclusion of non-member companies, but it looks as if TV sets were off in November. That was expected, as cutbacks had been announced.

It does not seem to explain the enormous increase in AM. The huge total of 1,256,099 is made up of 444,919 auto sets, 52,606 portables, and 758,574 home models.

The FM figure was probably not increased by the shift to reporting industry-wide production. November reached an all-time high since the synthetic FM models were dropped after 1948 because they did not give true FM performance.

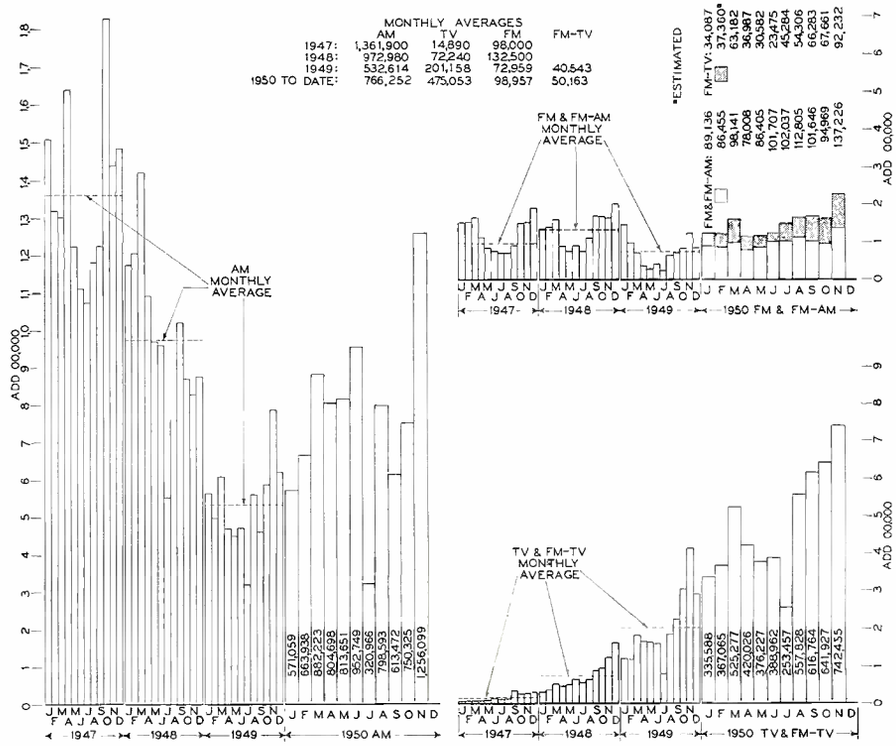
A comparison of average monthly production for 11 months in 1950 with the 12-month averages in '49 shows:

FM	'50 average,	up 36%
AM	" "	up 44%
TV	" "	up 136%

Cathode-ray tube shipments in November were slightly above the preceding month. The total was 914,804 units, of which 851,872 went to set manufacturers, and 61,938 were sold for replacement purposes. Of those sold to manufacturers 98% were 16 ins. or larger, and more than 60% were rectangular types.

Receiver tube shipments were 779,000 below October, but amounted to 39,326,641. Average for 11 months in '50 was 31,380,000. This indicates how greatly production was stepped up in the latter part of the year.

The November breakdown shows 31,327,152 units were sold to manufacturers for new sets 6,744,892 for replacements, 1,134,997 for export, and 119,600 for Government agencies.



TV, FM, and AM Set Production Barometer, prepared from RTMA figures

THIS MONTH'S COVER

The St. Paul radio system marks a new phase in the progress of radio communication. As Commissioner Peterson explains in this issue, selective calling and 2-frequency talk-back have made it possible, at a modest investment, to give added public service and to prepare for possible war emergencies without added manpower or increased payroll. Focal point of the system is the radio dispatcher's control console, illustrated on this month's cover.

SPOT NEWS NOTES

ITEMS AND COMMENTS, PERSONAL AND OTHERWISE, ABOUT PEOPLE AND COMPANIES CONCERNED WITH RADIO COMMUNICATIONS

Homing on AM Signals:

Watch for Government encouragement of FM receiver production under materials allocation plan. Reason is that, under emergency conditions, AM stations will be shut down so they cannot be used by enemy planes for homing on city targets. FM stations, however, have only primary coverage, and range is too short to be of value to enemy planes with FM receivers.

TV Color Appeal:

The U. S. District Court in Chicago signed an order on January 25, allowing RCA and seven interveners to appeal the color TV case to the Supreme Court of the United States.

New Plant:

McIntosh Engineering Laboratory has purchased a building of 11,000 square feet on a 5 acre plot at Binghamton, N. Y., and is erecting an adjacent building of 25,000 square feet. Added production of McIntosh amplifiers is already under way. Also, a new speaker and deposited carbon resistors will be manufactured there, as well as military equipment under subcontracts.

Phonevision Scrambles Sound:

With first phase of Phonevision tests completed, Zenith is testing scrambled sound, along with jittered pictures. So if you pick up channel 2 in Chicago and the audio isn't intelligible, that's the reason.

Emergency Power Plants:

Apropos of our remarks last month about the importance of emergency power sources for communication systems, Zellon Audritsh, APCO president has this to say: "There is a dangerous lack of independent, emergency generating units in our police departments. . . . This lack of vital equipment is truly the Achilles heel of our police emergency and disaster operations."

Their Slip Is Showing:

We wonder how much of the news in *The Boston Herald* is as inaccurate and incomplete as the information they carry on local FM stations. This paper lists WBZ-FM at 46.7 mc. That is some two years behind the times! WBMS-FM is still listed, although it has been off the air for months. Although WERS has raised its power, it *isn't* listed. Neither is WBUR or WXHR. In fact, *The Herald* scarcely gives recognition to its own station WHDH-FM.

Round to Rectangular:

Du Mont Laboratories has announced a new mask for TV tubes, designed to permit the substitution of a rectangular type 12QP4A for the round 12JP4 or 12RP4 types.

Air-Raid Sirens Inadequate:

The need of a radio alarm such as the FTB system was demonstrated in New York City on January 27. It was found that the siren sound does not penetrate business buildings and stores. Newspapers reported the next day that many New Yorkers thought the tests had been called off, although 803 sirens were sounded simultaneously.

Interest in High Places:

We never realized, until we started the series of articles on the FAS audio system that so many industry engineers and top executives are high-fidelity enthu-

(Continued on page 7)

SPOT NEWS NOTES

(Continued from page 6)

siasts. We've had a veritable flood of new subscription orders on the stationery of equipment manufacturers, research laboratories, broadcast stations, and concerns specializing in military production and development work. One that surprised us particularly came from the U. S. Naval Air Station at Memphis requesting a price quotation by air mail "to cover the cost for three (3) one-year subscriptions. We would like to have these start with the issue beginning the series of articles on the FAS Audio System."

Deposited Carbon Resistors:

It is expected that deposited carbon resistors will be used almost exclusively for U. S. Air Force electronic equipment. A new type, developed under the guidance of the Air Material Command's Electronic Subdivision, has a temperature coefficient of less than .1%, compared to 5 to 20% for composition or wire-wound types.

Personnel Changes:

W. Walter Watts, RCA vice president and general manager of the engineering products department, has been granted a leave of absence to serve with Major General William Harrison, Defense Production Administrator. His duties have been taken over by Theodore A. Smith, as assistant general manager of the department, while A. R. Hopkins has been named general sales manager.

Use of Noise Suppressors:

Squier Signal Laboratory reports that the use of resistor-suppressors on automobile engines does not make starting more difficult in cold weather. Tests on a car that had run 21,000 miles, and was in somewhat below average condition indicate that the resistors should improve cold-weather starting if they have any effect at all.

Civil Defense Spending:

It's all mixed up. Some states haven't actually made appropriations yet; others have appropriated funds but haven't spent them. In Connecticut, for example, Gov. Lodge asked for $2 million more, although it was announced on January 22 that, of the original $75,000 allocated to Civil Defense, $53,000 were still on hand.

Speaker Systems:

We have had quite a number of letters asking how the performance of the FAS speaker system compares with the Klipsch corner speaker. Of our F-A-S

(Continued on page 8)

SPOT NEWS NOTES

(Continued from page 7)

team, the Fowler part is currently doing his listening with various experimental FAS designs, and the Sleeper part is still using the Klipsch. Comparing notes, we are of the unanimous opinion that, as a commercial, packaged product, we would recommend the Klipsch because it combines fine performance, beautiful workmanship, and ease of installation. But if you want to go off on your own, the FAS will give you endless opportunities for experimenting until you reach the point where you have exactly what you want as to tone quality and method of installation.

University of Michigan:

When the parabola for WUOM's S-T transmitter was installed on one of the University buildings, it carried the letters REL painted in large characters. So many people asked if the name of the University had been changed that it was decided to change the letters to WUOM.

Amplifier Units:

A highly flexible series of amplifier units has been announced by ModulaR Audio Corporation, 1546 2nd Avenue, New York 28. Matched in mechanical design and size, they can be set up quickly in any combination for radio and phonograph installation. Literature is available on request.

Precision Resistors:

Deposited carbon resistors are being manufactured under Western Electric license by Wilkor Products, Inc., 2882 Detroit Avenue, Cleveland 13B, Ohio. Similar in appearance to composition types, they are being produced in ¼, ⅓, ½, 1, and 2-watt sizes. With a temperature coefficient rated at 20 parts per million per degree C., they are intended particularly for high-frequency communication equipment.

More FM Listeners:

Station WASH reports that the latest survey in Washington, D. C., by the American Research Bureau shows a current monthly increase of 4,000 FM sets in that area.

Microwave Equipment:

A 64-page catalog of measuring instruments has just been issued by Kay Electric Company, Pine Brook 2, N. J. Copies are available on request.

Convention Dates:

To avoid conflict, the West Coast Electronic Manufacturers' Association has set their annual show for August 22 to

(Continued on page 9)

SPOT NEWS NOTES

(Continued from page 8)

24, while the NEDA show at Cleveland will be held September 11 to 13.

Channelizing Equipment:

Lenkurt Electric Company, San Carlos, Calif., has announced new type 42C carrier equipment of low cost and great flexibility. Building-block designs can be combined for high-quality telephones circuits and signaling facilities. A technical bulletin illustrates various alternative arrangements.

Recorders for Telemetering:

A 2-pen instrument, designed to record two functions simultaneously against time, is described in a bulletin from Leads & Northrup, 4934 Stanton Avenue, Philadelphia 1. Chart speed can be selected in the range of 1 to 1,800 ins. per hour.

Spark Transmitters:

It was only 12 years ago, at the international radio conference at Cairo, that spark transmitters were outlawed.

Harry R. Smith:

Former senior development engineer of Du Mont's transmitter division is now in charge of TV transmitter development for Standard Electronics Corporation, 25 W. 43rd Street, New York.

Wages of Sin:

It may be true that crime does not pay, but sponsors are certainly making capital of it on audio and TV programs.

Dr. Allen B. Du Mont:

As far as we know, he is the youngest top executive in any major radio company. He celebrated his 50th anniversary on January 29.

Looking Ahead:

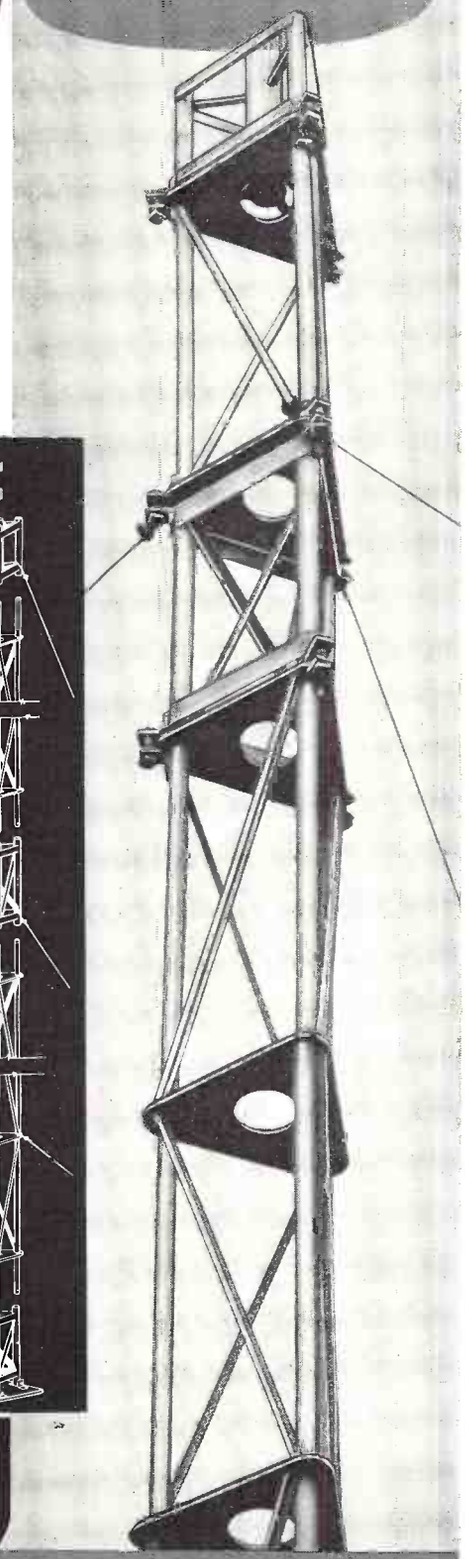
Not even the FCC should be disappointed that conditions brought about by the national emergency have stopped off color television. Before the end of this period, further research on military electronic equipment will undoubtedly contribute to the perfection of TV color transmission and reception.

You Dream in Black-and-White:

Speaking of color: have you ever seen any color in your dreams? Although agreement is not altogether unanimous, it appears quite certain that we dream without benefit of color. Flames, for example, are simply white light. Automobile are black. There may be blondes and brunettes in your dreams, but no red-heads. Make a check on your dreams and see if you agree.

HE OWER OF STRENGTH

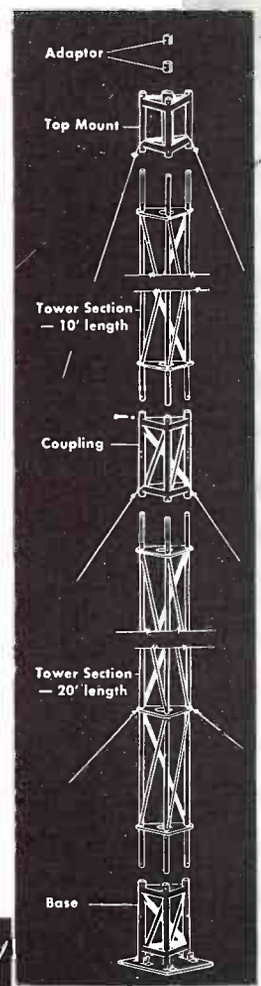
IDEAL FOR
COMMUNICATIONS
MICROWAVE
TELEVISION
LIGHTING



Superior construction features give LOW COST Vee-D-X sectional towers the highest safety factor of any tower in its price class.

If you have an elevated installation problem, absolute permanency of your installation is assured when you use a VEE-D-X sectional tower. Strength is a major factor. Don't take chances with structural failure. Be sure with VEE-D-X!

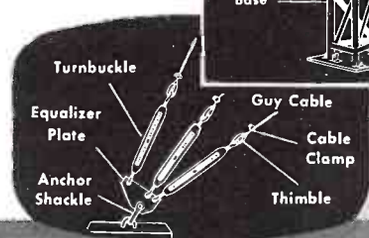
- *Rugged, all-welded construction diagonally laced with angle iron for maximum rigidity.*
- *Can be erected on ground or on flat or peaked roof.*
- *Patented plate spaced at two foot intervals prevents twisting and affords rigidity found in no other tower.*
- *Safe and easy to climb.*
- *Completely galvanized, light weight tubular steel . . . 20 ft. section 72 lbs.*



PRE-ASSEMBLED
for fast, inexpensive installation

VEE-D-X towers are designed for use at any height from 10 to 140 feet. They are self-supporting up to 20 feet and, where space is limited, *semi-guyed** type installations may be used at 30, 40, and 50 foot heights. Sketch at right shows the basic parts and necessary accessories for a complete installation. Three types of top mount are available. VEE-D-X towers may be ordered in separate units or as a complete package for a specific height. (Either guyed or semi-guyed.) Write the LaPointe-Plascomold Corporation of Unionville, Conn. for complete information.

*Semi-guyed towers employ one set of guy cables attached at a height of 10 ft. up the tower and anchored at a 6 ft . radius from the base.



VEE-D-X

BUILDERS OF THE WORLD'S MOST POWERFUL ANTENNAS

WHAT'S NEW THIS MONTH

THE FTB AIR-RAID ALERT ALARM — COMMISSIONER STERLING'S COMMENTS ON RADIATING RECEIVERS — MORE PRECISION TEST EQUIPMENT IS NEEDED

SINCE the announcement last month of the series of articles on the FTB air-raid alert alarm, starting in this issue, we have had many letters asking about making the information available for distribution to municipal and Civil Defense officials.

We shall be glad to cooperate with those who work out plans for local FTB systems.

Accordingly, if you want copies of RADIO COMMUNICATION Magazine containing the FTB series sent to officials in your community, simply send us their names and addresses. Then the issues of February, March, and April will be mailed to them without charge.

WITH TV receiver sales now beyond the 10 million mark, radiation interference has assumed serious proportions in many parts of the Country. The causes of this situation, the FCC Rules related to it, and RTMA president Robert Sprague's recent letter to the set manufacturers were discussed by Commissioner George Sterling in an address at the IRE and Industrial Electronics Organization Meeting at Cleveland on January 25. On this subject, Commissioner Sterling said:

By regulation and cooperation of industry, we have moved forward in reducing interference without impairing or restricting the operation of diathermy machines and industrial heaters and other devices. But a new menace to air navigation and to radio services recently reared its ugly head. I refer to excessive oscillator radiation from FM, TV, and communication receivers. As many of you know, radio receivers today are almost exclusively of the superheterodyne type, and hence have built into them an oscillator or generator of radio-frequency energy. In other words, they are transmitters of low power but they can inflict severe damage if not controlled. It is by the means of this oscillator that the incoming frequency is converted to the intermediate frequency where it is amplified, detected, and passed on to produce either aural or visual information, or both. These oscillators, unless properly shielded and filtered, radiate their energy either directly or by coupling to the receiving antenna and experience has shown that both FM and TV receiving antennas are fairly efficient radiators. While oscillator radiation not only interferes with other services it also interferes with the TV service itself. The problem is bad enough now with 107 TV stations on the air and over 10 million receivers in the hands of the public. You can well imagine what it will be unless prompt action is taken by the manufacturers or the Commission once the freeze is lifted, and hundreds of new stations are on the air and the number of receivers climb into new millions.

On April 12, 1949, the Commission adopted proposed rules which were aimed at restricting oscillator radiation from TV and FM sets to 15 microvolts per meter at 100 feet. I hope it will not be necessary for the Commission to take drastic action in connection with this problem. I am sure it will not if receiver manufacturers respond wholeheartedly to the recommendations and plea made by Mr. Robert C. Sprague, President of the Radio-Television Manufacturers Association in his letter of December 14, 1950, sent to all TV and FM receiver and tuner manufacturers as a result of conferences held between committees of RTMA Engineering Department and Curtis Plummer, our Chief Engineer, and his staff. By permission, I quote from parts of Mr. Sprague's letter:

"My conversations with the members of the Federal Communications Commission and the staff have convinced me that unless the industry as a whole conforms to the new standards and further improves upon these standards as rapidly as the art permits, a solution to the problem may be sought through Government regulatory action, perhaps even by subjecting our entire industry to some form of certification for the products of the receiver manufacturers. . . .

"I urge that regardless of the increase in cost, which does not appear to be great, you instruct your engineers to conform to the standards which will be circulated to the industry and which are as follows:

"1. For TV channels 2 to 6, an average of less than 50 microvolts per meter at 100 ft.;

"2. For TV Channels 7 to 13, an average of less than 150 microvolts per meter at 100 ft.;

"3. For FM, less than 60 microvolts per meter at 100 ft."

I know that Mr. Sprague has taken a very active interest in this problem and I, for one, would like to commend him for his effort.

But oscillator radiation is not the only interference that originates from the operation of a TV receiver. Manufacturers must do something immediately concerning the interference that results from the harmonics of 15.75-kc. horizontal sweep frequency and video circuits. This form of interference was not serious in the earlier TV sets, but has increased considerably within the year as some manufacturers cut down on shielding and filtering to meet a competitive market. Not all current models are offenders. Radiation of harmonics and hash from TV receivers interfere with airports, commercial circuits, and the amateur service, and even broadcast service. Tune across the standard broadcast band sometime and listen to the beeps and hash from your own or neighbors' TV receivers.

OUR frequent references to the necessity of precision test equipment for maintaining communication systems at peak efficiency were confirmed recently by no less an authority than Dr. E. U. Condon, Director of the Bureau of Standards, in an address before the Conference on High Frequency Measurements:

"The necessity for test equipment and procedures required for proper maintenance and optimum operation must be fully appreciated. There is clearly no logic in developing powerful and elaborate electronic tools if they are to be used ineffectually or sporadically as a consequence of operation and maintenance problems. Yet experience gained in the last war revealed that there were far too many occasions when precisely this did happen. The experience of a submarine commander during the last war may well serve as a biting example. This commander reported that he sank 7 Japanese ships after his radar system had been properly equipped with test gear and suitable check points. Previously insufficient radar range had prevented him from locating the enemy at all. The insufficient range was the result of his inability to tune the radar properly which he could not do without test gear and check points."

It has been our observation that many communication systems today are paying a penalty for inadequate maintenance through the unnecessary reduction of transmitting range, and messages garbled by noise and interference.

FTB AIR-RAID ALERT ALARM

PART 1: WHY CIVIL DEFENSE NEEDS RADIO-OPERATED ALARMS — HOW THE FTB SYSTEM PROVIDES FAIL-SAFE OPERATION — *By* FREDERICK T. BUDELMAN*

ALL plans for protecting our cities against air attack are predicated on minimizing interruptions to normal production activities. Basically this requires that advance warnings of threatened attack be transmitted only to authorized Civil Defense personnel who must take up their assigned posts and duties before any general alarm is sounded.

The reason is two-fold. First, extra time is required to make the advance preparations for an air-raid. Second, experience in the last war indicated that many threatened attacks can be beaten back and, therefore, do not materialize. If general alarms are sounded in such cases, they may have an adverse psychological effect, with the result that unnecessary panic may be caused, or a feeling of careless indifference may be developed. Moreover, production work would be interrupted needlessly.

Speed is Essential:

Conditions are different now. In point of distance, some of our most important inland cities are within easy reach of round-trip bombers, capable of such speed that they can travel miles in the time required to put in a phone call and get an answer.

Radio broadcast and communications transmitters offer the only means of reaching all Civil Defense personnel simultaneously. There are some 700 FM broadcast stations available for this purpose. In addition, we have about 17,000 transmitters in the police, fire, taxicab, public utility, and other emergency services. Most of them operate on a 24-hour schedule.

Requirements of a Radio Alarm:

The reason that the use of radio transmitters has not been considered is that no design for a radio-operated alarm has been available up to this time. Here are the basic specifications for an acceptable system:

1. It must be inexpensive to build, and dependable in operation. An air-raid alert alarm may be in operation for months without being used, but it must be in operating condition at all times.

2. The equipment must be adaptable to any FM broadcast or communication transmitter, without interfering with normal operation. At the receiving end, the alarm must not interfere with normal reception. The alarm must operate whether the speaker volume is turned up or down.

3. It must be capable of transmitting an alarm to all concerned simultaneously, and without delay.

4. It must give a continuous indication of the exact status of the warning system *i.e.*, all clear, alert, or actual raid warning.

5. It must be fail-safe in operation, so as to show that the system has been disrupted in case of failure at either the transmitter or the receiver.

6. Finally, it should be possible to operate two or more such systems, if required, in a given area.

How the FTB System Works:

The FTB system, as it has come to be called, is designed to meet the specifications set forth above. It is based on the transmission of audio signals by radio, although wire circuits can be used also. Fig. 1 is a block diagram showing the control unit and radio transmitter, and the receiver and alarm.

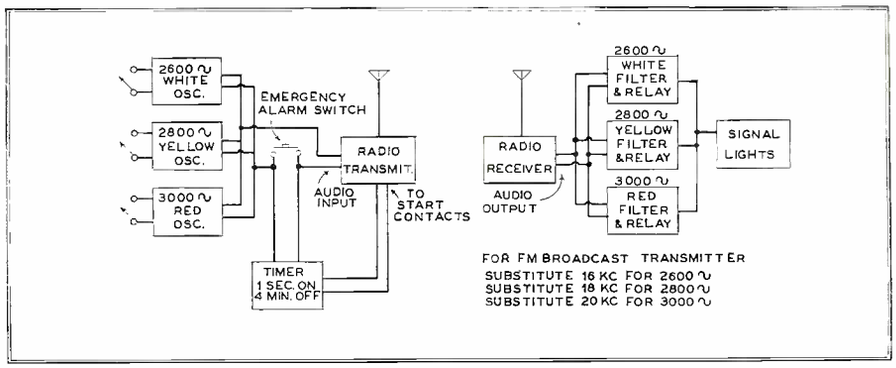


FIG. 1. PLAN FOR COMMUNICATION OR FM BROADCAST TRANSMITTER, AND THE RECEIVER LIGHTS

The control unit has three audio oscillators to generated frequency A corresponding to a white or all-clear signal; frequency B for the yellow or alert signal; and frequency C for the red or actual air-raid warning.

For use at radiophone communication transmitters, the frequencies of 2,600, 2,000, and 3,000 cycles have been chosen so as not to interfere with message traffic. On FM broadcast transmitters, supersonic frequencies of 16, 18, and 20 kc. have been used.

Under normal all-clear conditions, tone A is transmitted for about 1 second during each 4-minute period. This tone, received on any appropriate radio receiver tuned to the master transmitter, is applied to the alarm indicator. This device employs three tone-filter relay circuits responsive respectively to tones on frequencies A, B and C. When a 1-second tone is received on frequency A, relay A is energized and white lamp W is illuminated. Relay A is locked in through the time-delay circuit which will hold the relay and keep the white lamp lit for approximately 5 minutes. This time delay circuit is reset each time any of the three tones is received and, therefore, the lamp will remain lit as long as a tone is received in every 5-minute period.

The transmission of a 1-second tone on frequency B will cause relay B to be energized, and the yellow lamp Y to be illuminated, while the white lamp goes out, since its relay will no longer be kept closed. The same periodic tone transmission system will keep the yellow lamp lit through the time delay circuits. The red signal operates in a similar manner.

The important feature of the system is its reliability of indication. It is apparent that *any* failure in the entire chain of functions leading to the final indication will cause the lamp to go out, giving an immediate warning of trouble. All circuits are so arranged that no normal type of failure can cause a lamp to stay illuminated. Therefore, one of the three lamps will be lit *only* if the complete air-raid warning system is in complete and perfect operation. This fail-safe feature makes it possible to rely on the FTB alarm system for primary alarm networks with a greater expectation of reliability than teletype and phone circuits which are much more vulnerable to bomb damage, sabotage, human errors and delays in transmission.

Auxiliary controls can be provided on relays A, B, and C so that auxiliary sig-

*Vice President in Charge of Engineering, Link Radio Corporation, 125 West 17th Street, New York City.

nals or various alarms can be activated.

One feature of radio transmission of air-raid alarms that cannot be stressed too strongly is its non-vulnerability to sabotage or weather conditions. The State Police teletype systems in several states on the eastern seaboard were completely disrupted recently during a severe storm. In addition, service to millions of telephone subscribers was cut off for periods of one to five or more days at that time.

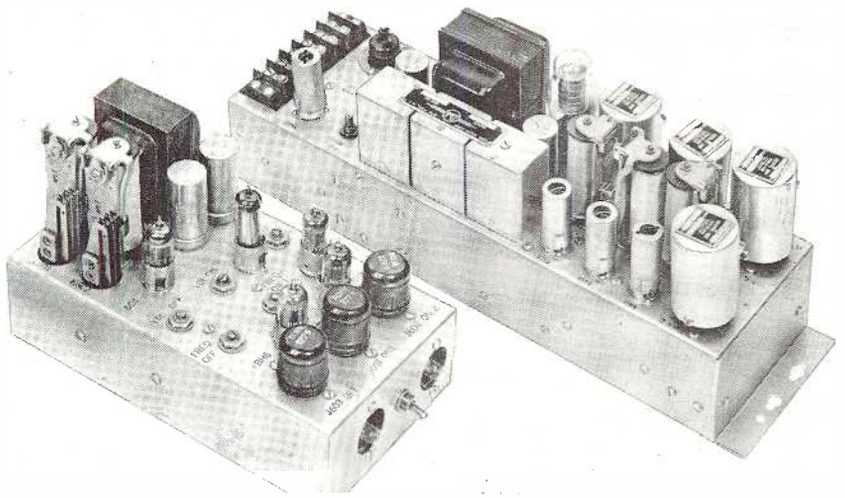


FIG. 2. A 3-CHANNEL R-C OSCILLATOR FIG. 2. BEAT-FREQUENCY TYPE FOR SUPERSONIC SIGNALS

Fail-Safe Operation:

Not the least important feature of the FTB system is the security and reassurance provided by its continuous, 24-hour operation. The white light is confirmation of safe conditions, and the fact that one of the lights is always on removes any doubt as to the operating condition of the system.

This operating principle has been adopted universally for fire alarm systems, on the basis of many years' experience. It is recognized that an alarm box mechanism or the connecting wire circuit may fail. Therefore, closed-circuit operation is employed so that any failure that would open the circuit and disable an alarm box releases a relay at fire-alarm headquarters. Immediately, therefore, the location of the failure is known, and appropriate steps can be taken to remedy the trouble. This long-proven principle is used in the FTB system.

Signal Transmission:

The tone-generating equipment used at the communications or broadcast transmitter may take many forms. The only requirement is that it provide a stable and reliable source of three tones. Frequencies 2,600, 2,800, and 3,000 cycles are suggested for communication transmitters and 16, 18, and 20 kc. are suggested for FM broadcast transmitters. The method of control and keying will depend of course on how the equipment is coordinated into the overall area air raid warning system. Figs. 2 and 3 illustrate typical commercial models of three-frequency tone generators. Fig. 2 shows a generator capable of delivering three medium frequency tones. Stabilized R-C oscillators are used for simplicity and the output is arranged to bridge across a 500-ohm transmitter audio input circuit without causing a mismatch. Fig. 3 illustrates a highly stable crystal-controlled beat-frequency oscillator for generating any three frequencies up to 30 kc. for use in FM broadcasting stations.

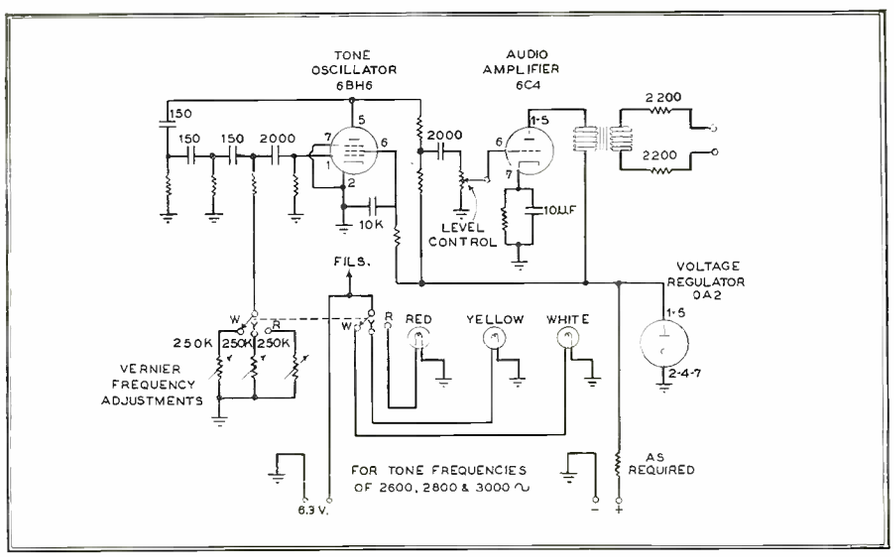


FIG. 4. ELEMENTARY DIAGRAM FOR A SUITABLE 3-CHANNEL AUDIO-FREQUENCY R-C OSCILLATOR

The use of crystal-controlled oscillators insures absolute stability of the transmitted tones. These commercial models are available in several forms and usually are completely self-contained, including power supply. Just how simple the three-frequency oscillator may be is shown in the schematic in Fig. 4.

Radio Amateur Organizations:

With the assignment to radio amateurs of special frequencies for civil defense communication, the way has been opened for them to take an active part in supplementing the emergency services. However, amateurs cannot stand continuous watch, nor can they keep loudspeakers turned on 24 hours a day. Yet, as is true of C-D personnel, local amateur groups should be alerted as soon as word of a threatened air attack is received.

For this purpose, either of two methods can be employed: 1) if an FTB system is set up for the local C-D organization, each radio amateur can equip himself with an alarm device, or 2) amateur organizations can operate their own signal transmitter, operating on one of the assigned amateur frequencies, to actuate their own alarms. This would not cause any interference, since the tone signal is of such short duration, and is transmitted once in four minutes.

Building FTB Units:

The signaling and alarm units for this system have not been manufactured commercially. Now the time is short and the need is urgent. Fortunately, the units are simple, inexpensive, and easy to build from standard parts available from local or mail order supply houses.

Broadcast and communication engineers and radio amateurs can readily construct and install the equipment. Moreover, they are in the best position to handle such an undertaking because of their personal contacts with Municipal and Civil Defense Organizations. Funds are already available in most areas or will be very soon to purchase equipment.

Accordingly, detailed design and circuit information will be presented on the FTB units using standard components.

Editor's Note: Part 2, to be published next month, will describe the 3-frequency signaling device.

JEREMIAH COURTNEY'S

MOBILE RADIO

NEWS AND FORECASTS

THE special industrial radio service has probably raised more questions of eligibility than all the other mobile services combined. Not the least important of these questions was that of the eligibility of ready-mixed concrete trucks for radio use.

Under the special industrial Rules, radio is not available for "activities of a service or distribution nature." Radio may be used for manufacturing, construction and production activities, however. Question: Are ready-mix cement trucks engaged in a radio-prohibited delivery operation or a radio-permitted manufacturing or production activity?

Radio for Mixer Trucks:

The Commission has finally and favorably resolved this particular eligibility question in connection with the application of Graham Bros. Inc. of Los Angeles, holding:

"A review of the facts set forth in the application and supplementary statements indicate that the applicant proposes to use radio to control the production of concrete. The fact that such production continues through to delivery of the final product to the job where it is used does not, we believe, make this a delivery operation of the type we intended to exclude from the special industrial radio service (see Commission Report and Order of April 27, 1949). Accordingly, we find that the operations of Graham Bros., Inc. as set forth in its application fall within the basic eligibility requirements of Section 11.501 (a) of the Rules."

The decision in this proceeding has opened up a whole new field of radio sales and released for processing the various cement-mixer applications held in abeyance since July 1, 1949, pending decision of this general eligibility question in the Graham Bros. proceeding. As a result, cement-mixing trucks may now use radio on construction projects of a public character without territorial limitation, and on private construction jobs outside urban areas. The present restriction on private urban jobs doesn't have too much significance at the moment because it appears that an increasing percentage of all construction jobs will henceforth fall in the "public character" category.

Civil Defense Decision:

The Commission has announced that the nation's amateurs will not be closed down "because of war or other national emergency" as they were in World War II. Reason: "The Civil Defense Administration has brought to the attention of the Commission the fact that licensed radio amateurs may be requested by the appropriate local Civil Defense authorities to provide communication or to supplement other existing communication systems for civil defense purposes."

The bands available for civil defense use by amateurs are:

1800-2000 kc.	50.35-50.75 mc.
3500-3510 kc.	53.35-53.75 mc.
3990-4000 kc.	145.17-145.71 mc.
28.55-28.75 mc.	146.79-147.33 mc.
29.45-29.65 mc.	220-225 mc.

This formal announcement following combined study by the Commission, the Civil Defense Administration, and the Armed Forces of the United States, is highly important not only to amateurs (in settling the portions of the regular amateur bands available to provide civil defense communications after any suspension of normal amateur activity) but to the mobile services as well. In the last war, the amateurs were closed down so that the military might use their assigned frequencies. The mobile services authorized at that time were continued, however, in the interest of conserving much-needed man-power and equipment. Since amateur activities are to be continued for civil defense purposes even in the event of war, the implication is inescapable that the mobile radio services will likewise be continued. Any other decision would most seriously retard the defense effort and the maintenance of the civilian economy now so dependent in all its aspects—industrial, transportation, production, public utility service, etc.—on mobile radio use.

Importance of Mobile Services:

In transmitting its annual report of activities to Congress, Chairman Wayne Coy specifically called attention to the growth of the mobile radio services and their relation to the domestic economy: "The attention of Congress is invited, in particular, to the little-publicized yet highly important developments in the non-broadcast field. Here new and augmented services have a material public impact in utilizing radio for the protection of life and property, as adjuncts to commerce and industry, and in furthering common carrier telephone and telegraph service." Copies of the report are available from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. at a cost of 40 cents.

New Antenna Rules:

The FCC has finalized its new Part 17 Rules governing the construction, marking, and lighting of antennas and towers. The new Rules set forth the criteria for determining whether a proposed antenna will require special aeronautical study. In general, the new Rules provide that no aeronautical study will be required for antennas and towers under 170 ft. in height except when the proposed location falls in the vicinity of airports and approach areas, or an established coastal corridor in which low-level flight is required for Department of Defense and Coast Guard operations conducted from air stations located within 20 statute miles of the Atlantic, Pacific, and Gulf Coast.

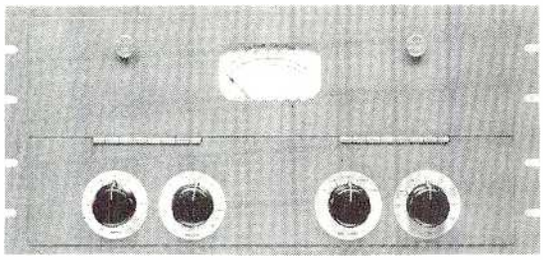
The second major exception is for antennas 20 ft. or less in height above ground, or if mounted on a natural formation or existing man-made structure, when the over-all height of the formation or structure will not be increased in excess of 20 ft. Such antenas will be cleared by the FCC without reference to the Regional Airspace Subcommittee of the Air Coordinating Committee.

If a special aeronautical study is required to determine whether or not the tower constitutes a hazard to aviation, the application will be referred by the FCC to the Regional Airspace Sub-committee. Since such references may result in a serious delay to the processing of an affected application, the criteria for determining if an antenna structure will require special aeronautical study will be summarized briefly in an early issue.

FCC's Interference Sleuths:

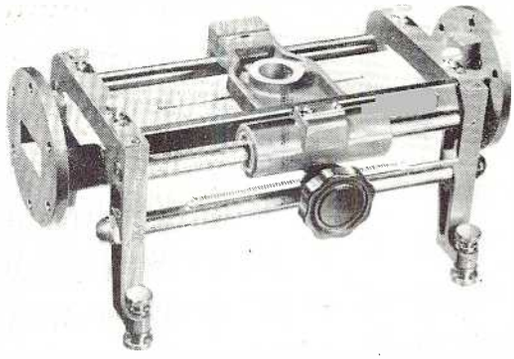
Commission engineers are doing an excellent job of protecting communication systems from interference caused by industrial heating equipment used in various manufacturing processes. Trouble is due to off-frequency operation in most cases. In one case, interference at Bermuda airport was traced to heating equipment at a Pennsylvania chair factory.

*1707 H Street, N. W., Washington, D. C.



1. RCA LIMITING AMPLIFIER AND POWER SUPPLY

2. JAMES KNIGHT'S VACUUM CRYSTAL MOUNT



3. HEWLITT-PACKARD PRECISION CARRIAGE

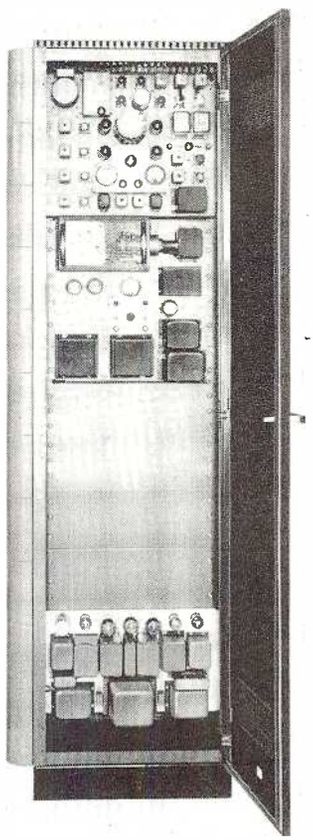
NEWS PICTURES

1. The RCA type BA-6A equipment comprises an amplifier and power supply of plug-in design. Plate and heater current are available for a preamplifier, if additional gain is required. Frequency response is rated at approximately ± 1 db from 30 to 15,000 cycles, with harmonic distortion less than 1% RMS from 100 to 15,000 cycles at 15 db gain reduction. At the verge of limiting, maximum output level is 30 dbm, and signal-to-noise ratio 83 db. Compression ratio above verge of limiting is 20 db into 2 db, with an indicated gain of 54 db below verge of limiting.

2. A new G series of crystals, hermetically sealed in vacuum, is going into production at James Knights Company, Sandwich, Ill. At present, they are only available in the range from 90 to 200 kc., although this type of mounting will be used later for crystals of higher frequency. Advantage is that thermal insulation reduces the temperature change of the crystal to a fraction of a degree during a theromstat cycle of several degrees.

3. This illustration shows the model 809B Hewlett-Packard single precision carriage which accepts either slotted waveguide or coaxial sections covering 4,000 to 12,400 mc. Slotted waveguide sections for this carriage are 2 by 1, 1½ by ¾, 1¼ by ⅝, and 1 by ½ in. There is also a slotted coaxial section for 3,000 to 12,000 mc. Other items include attenuators, adapters, detector mounts, freqency meters, slide screw and E-H tuners, klystron power supplies, UHF and SHF signal generators.

4. RCA has an S-T link transmitter,



4. RCA S-T LINK OPERATES ON 890 TO 952 MC.

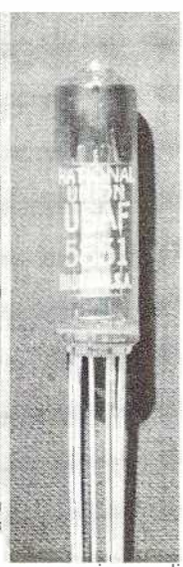
type BTL-1A, for operation on 890 to 952 mc. It is intended for use by FM and AM stations, and for the audio channel of TV stations. The exciter is a modified version of RCA's direct-FM unit, with an output at 50 mc. This followed by a doubler and two triplers, the latter being an air-cooled 4X150A power tetrode. Output is 3 watts. A crystal-controlled, double superheterodyne circuit is used for the receiver. System specifications show audio response within 1 db from 30 to 15,000 cycles, less than 1% distortion from 100 to 7,500 cycles, and not more than 1.5% in the lower and higher ranges, with signal-to-noise ratio better than 65 db below 100% modulation.

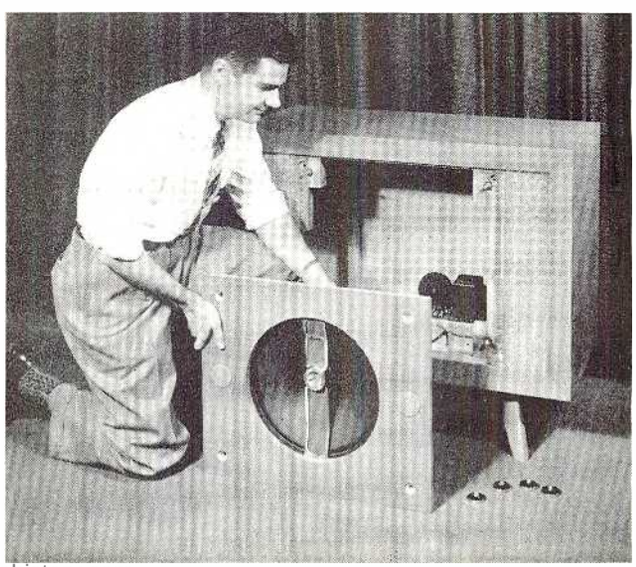
5. A very clever type of assembly jig has been designed by Potter & Brumfield, relay manufacturers at Princeton 3, Ind. A cast iron sphere, carried on a ring base, has a quick release clamp to hold the work. Thus, while the work can be moved readily, it is kept firmly in position by the weight of the sphere.

6. The National Union type 5851 is a T-3 subminiature beam pentode designed to withstand shock and vibration of military applications. Used as a frequency doubler up to 400 mc., it is rated at .12 watt output. As a class A amplifier, it delivers .65 watt audio at 10% total harmonic distortion.

7. The design of this Jensen Custom-ode speaker cabinet incorporates an improvement so obvious it seems surprising that someone didn't think of it long ago. Instead of mounting the front panel permanently on the cabinet, and using a removable back for access to the speaker, this new design reverses the arrangement.

5. POTTER & BRUMFIELD'S ASSEMBLY FIXTURE 6. NATIONAL UNION SUBMINIATURE PENTODE 7. JENSEN HAS A NEW CABINET IDEA





COMMUNICATION SYSTEM MONITOR

THIS HEWLETT - PACKARD INSTRUMENT MONITORS BOTH FREQUENCY AND MODULATION ON 1 TO 4 CHANNELS BETWEEN 30 AND 175 MC.—*By* J. E. STILES*

THE growth of new assignments in the already crowded mobile communications spectrum has indicated the need for adequate monitoring equipment. Adjacent-channel interference can be avoided only by frequent and accurate measurement of the peak modulation swing as well as the carrier frequency of the fixed and mobile transmitting equipment used in this service.

The Hewlett-Packard FM Monitor, model 337, illustrated in Figs. 1, 2, and 3, has been designed to monitor the transmission of FM signals in the mobile communications bands, as required by the FCC. This instrument provides simultaneous measurement of the carrier frequency and the peak modulation swing with an accuracy well within the prescribed limits. Simplicity of operation has been realized by the use of circuits that require no adjustment prior to making measurements. The sensitivity of the monitor is better than 400 microvolts. This makes it possible to monitor semi-remote mobile transmitters, as well as fixed transmitters of higher power.

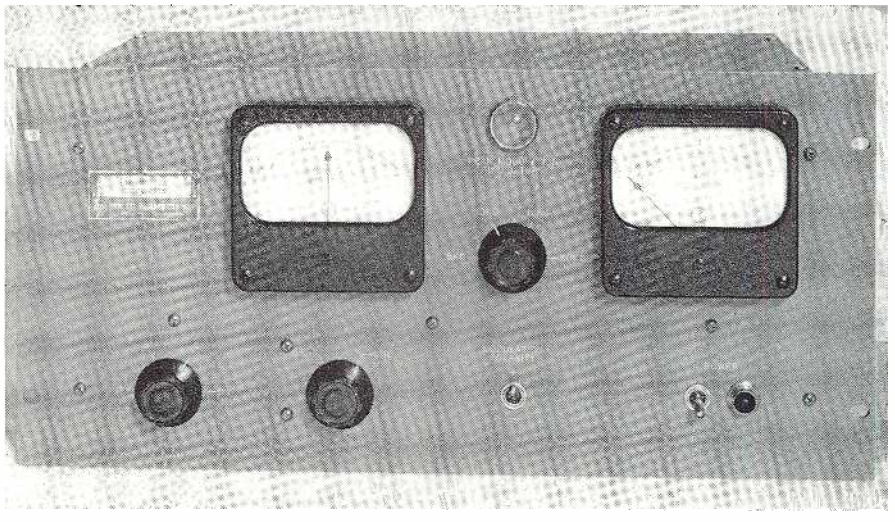


FIG. 1. H-P FREQUENCY AND MODULATION MONITOR FOR ANY 4 FREQUENCIES FROM 30 TO 175 MC.

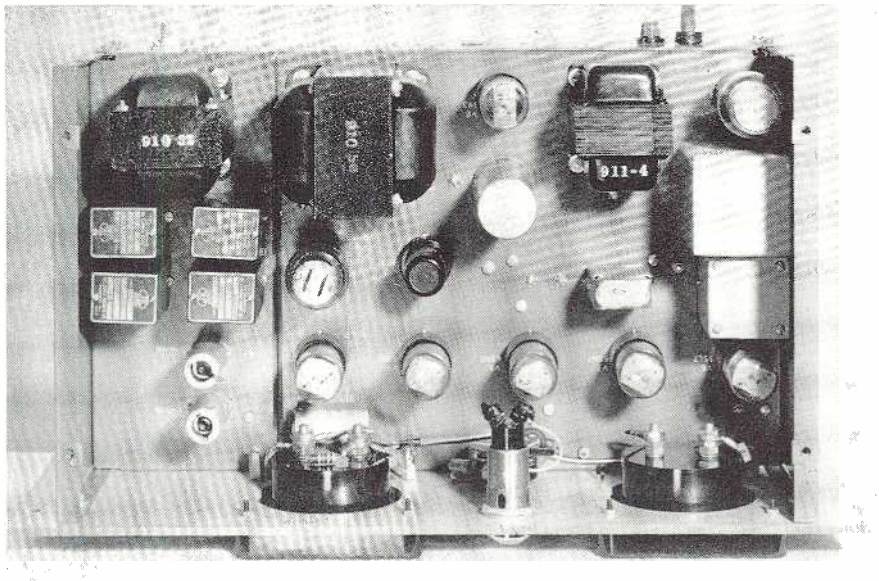


FIG. 2. TOP VIEW OF THE MONITOR CHASSIS. FOUR CRYSTAL OVENS ARE MOUNTED AT THE LEFT

Two models of this instrument are available. One monitors transmission on any single frequency in the range of 30 to 175 mc. The other monitors up to four frequencies in this same frequency range. The latter unit is equipped with a panel switch to select the desired channel for operation. No plug-in coils are used. Apart from the single- or multiple-channel features, the two models are identical. In unusual cases, a unit can be provided to use in conjunction with the basic Model 337 for extending the number of monitoring channels from four to sixteen.

Electrical Design:

The electrical design of this monitor is essentially the same as that of the Hewlett-Packard model 335B FM broadcast monitor. Figure 4 shows a block diagram of the circuit arrangement.

The output of a temperature-stabilized crystal oscillator is multiplied as required to generate a 30-kc. mean IF when combined in a mixer with a signal from the transmitter under test. The output of the mixer is fed through a series of limiting and squaring amplifiers to a pulse-counting type of discriminator. The DC component of the discriminator output is used to operate the carrier deviation meter, and the AC or audio component is amplified to operate a peak-reading voltmeter to indicate modulation swing. The output of the audio amplifier is also used to operate the peak modulation indicator, and to supply an audio output for aural monitoring or measurement purposes.

Reference Oscillator & Multiplier:

The basic accuracy of any frequency monitor is, of course, dependent on the accuracy of its standard or reference oscillator. In this monitor the reference oscillator employs a hermetically-sealed plated crystal, operating in a temperature-stabilized oven. Configuration of the oscillator-multiplier is that of a tuned-plate-tuned-grid oscillator, with the crystal in the grid circuit and the screen grid of the pentode tube acting as the plate of the oscillator. The resonant element in the screen circuit is tuned slightly above the crystal frequency. The plate tank circuit is tuned to a suitable harmonic of the crystal frequency, depending on the multiplication required. Fig. 5 shows the basic reference oscillator circuit. An incremental frequency control is supplied in the form of a small

* Development Engineer, Hewlett-Packard Company, 395 Page Mill Road, Palo Alto, Calif.

variable condenser shunting the crystal. An unmarked detent between the CARRIER LEVEL and USE position of the panel selector switch inserts the 1-milliampere modulation meter in the grid circuit of the mixer tube to facilitate

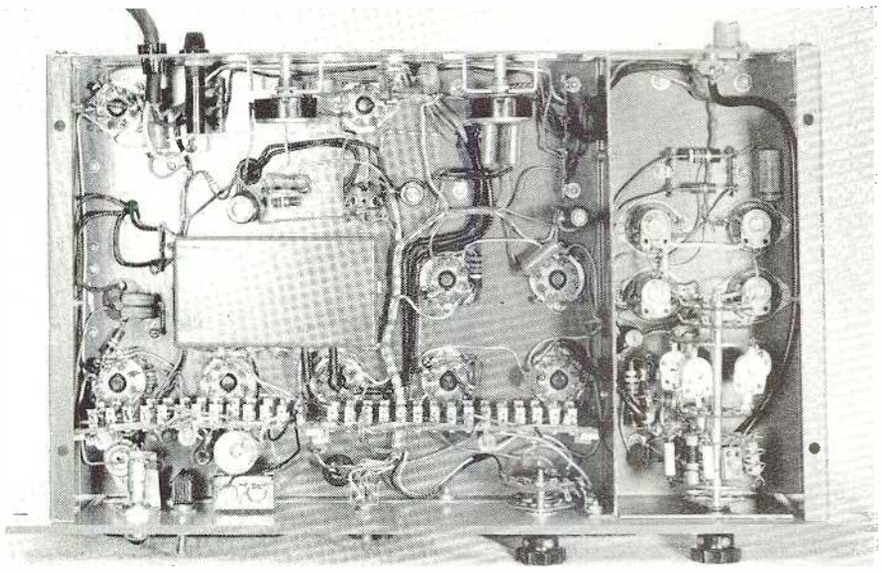


FIG. 3. BOTTOM VIEW SHOWS THE CRYSTAL SWITCH IN THE RIGHT HAND SHIELDED COMPARTMENT

the tuning of the oscillator-multiplier circuits should a new crystal be installed in the field.

A high order of frequency stability has been obtained from this reference oscillator. Typical stability curves are shown in Fig. 6. The crystal oven-heater current is derived from a transformer that is connected ahead of the main power switch, so that oven temperature is maintained at all times when the power cord is connected.

Mixer Circuit:

The mixer circuit employs a 6BE6 tube in a conventional arrangement. The antenna is coupled to a tuned circuit resonant to the transmitter frequency. Signals developed across this tuned circuit are applied to the mixer tube signal grid. The output of the reference oscillator-multiplier is coupled to the mixer-tube oscillator grid, and the IF signal is developed across the plate load resistor. At transmitter frequencies above 44 mc., the incoming signal beats with harmonics of the oscillator-multiplier injection frequency. Satisfactory conversion gain is obtained even when the input signal is beating with the 5th harmonic of the oscillator injection frequency. The capacity of a shielded cable connecting the IF signal to the subsequent circuits acts as a by-pass to the high-frequency products of the mixer.

Limiting & Squaring Amplifier:

Because of the wide range of carrier levels anticipated in the use of this monitor, it would seem that considerable limiting of the IF signals would be required. However, the discriminator in this monitor is the pulse-counting type, and operates from a square waveform. The amplitude of the signals applied to the discriminator is not critical above a certain minimum value. Actually, the required limiting action is shared by the limiting and squaring amplifier and the discriminator, with the latter contributing the greater part to this function. The circuit of the limiting and squaring amplifier has three RC-coupled triode sections with a large value of resistance in series with each grid. Limiting and squaring take place when the impressed

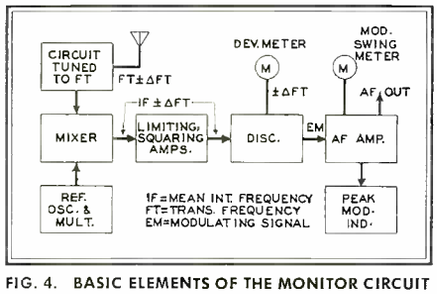


FIG. 4. BASIC ELEMENTS OF THE MONITOR CIRCUIT

signal causes any or all of the grids to draw current.

A measure of the overall limiting action is made by varying the amplitude of an IF signal at the input of the first amplifier, while observing the discriminator current. The variation in the discriminator current is negligible for input voltages ranging from .003 to 20 volts. Limiting over such a wide range obviates the necessity for adjusting the IF signal to some arbitrary level prior to making a measurement.

The C.L. position of the front panel switch inserts the moduluation meter in the grid circuit of the third amplifier tube. Any indication on the meter shows that grid current is flowing, and that there is adequate limiting for proper operation of the instrument.

Discriminator Circuit:

The salient feature of the electrical design is the use of a pulse-counter circuit as a discriminator, having many advantages over the tuned-circuit types. The pulse counter discriminator is inherently linear, and is substantially independent of amplitude variations. The stability is dependent upon four wire-wound resistors and two silver-mica condensers. No tuned circuits are required. Very low IF frequencies can be used, and, therefore, the stability tolerance imposed upon the discriminator is less stringent.

For example, suppose we can tolerate an error of ± 1 kc. in the deviation indicator. In the case of the tuned-circuit discriminator operating at 5 mc., the discriminator must have a stability of 1 part in 5000 or .02%. A stability of this order would be very hard to maintain, even for short periods of time, with tuned circuits, and a device for calibrating the discriminator would have to be used prior to making an accurate measurement. The pulse-counter circuit uses a 30-kc. mean IF. If the same 1-kc. deviation meter error could be tolerated, the tolerance imposed on the discriminator would be 1 part in 30 or 3.3%. The stability of this discriminator is better than 0.5% for very long periods of time, and requires no calibration device.

Figure 7 shows a simplified diagram of the discriminator. V1, V_2 are switching tubes. Their grids are fed from a phase inverter in the limiting amplifier circuit. V_3 is a regulator tube, arranged to provide a source of constant current. The square wave form of the IF signal supplies a switching voltage so that for half the cycle all the constant current I^0 flows through V_1, and on the other half of the cycle I^0 flows through V_2. R_1 and R_2 are identical, as are C_1 and C_2. The RC time constant is such that condensers C_1 and C_2 are fully charged in less than the duration of their respective half-cycles. A bridge rectifier is used to connect C_1 and C_2 to the carrier deviation meter M, so that the accurately-controlled current pulses through C_1 and C_2 are caused to flow through the meter in the same direction, as illustrated by Fig. 8. It can be shown that

$$Im = 2I^0RCF$$

where: Im = current through meter
I^0 = constant current
R = value of R_1 and R_2
C = value of C_1 and C_2

Then if I^0 is constant, and R_1, R_2, C_1, and C_2 are fixed components, Im is a linear function of frequency only.

Unless some further arrangement were

made, the carrier deviation meter would indicate changes in carrier frequency by some very small change in meter reading. A better system is obtained by using a zero-center meter, and balancing out the current produced by the mean IF with an equal current applied through the meter in the opposite direction. In this manner, a sensitive meter can be used and the desired deviation range can be spread over the full scale of the meter. Instability is avoided by deriving the balancing current from the constant-current source through a network composed of R_3 and R_4.

The carrier deviation meter uses a 200-microampere zero-center movement. The scale is calibrated in 1,000-cycle graduations to 15 kc. on each side of the zero center.

To extract the audio component from the discriminator the primary of an audio

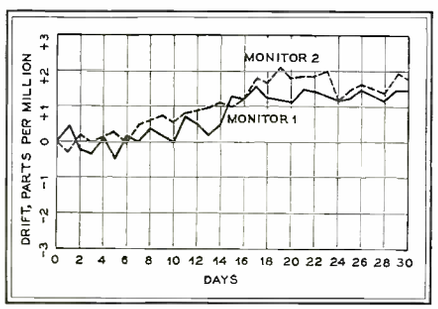


FIG. 6. PLOT OF DRIFT DURING 30-DAY PERIOD

transformer is connected in series with the carrier deviation meter. The AC voltage developed across the secondary of this transformer is proportional to the peak modulation swing of the applied FM signal.

Audio Amplifier:

The audio output from the discriminator is coupled to an audio amplifier consisting of the two triode sections of a 6SL7, and supplying a net gain of about 29 db. Negative feed-back on the order of 30 db is used to stabilize the amplifier, so that its gain is independent of voltage variations and tube replacement.

A low-pass filter at the input of the amplifier is designed to keep the IF signal out of the audio system. The cutoff frequency of this filter is about 5 kc., sufficiently high for the range of modulating frequencies encountered in communications work. The overall frequency response of the audio system is flat within $\pm$ ½ db from 50 cycles to 4 kc.

Modulation Meter & Flasher:

The output of the audio amplifier is fed through a cathode follower to a germanium crystal diode rectifier. Rectified voltage is applied across a condenser to the meter which indicates the peak value of the voltage. The low impedance of the cathode follower output allows the condenser to charge to the peak value of short bursts of modulation. The meter indicates the peak value of modulation swings within 5% for sine-wave modulating signals from 250 cycles to 4 kc. The

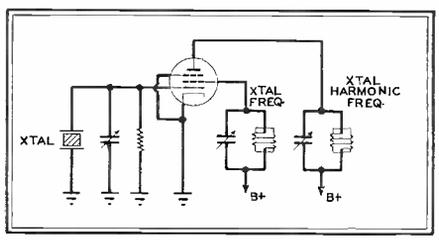


FIG. 5. CIRCUIT OF THE REFERENCE OSCILLATOR

modulation meter has a 1-milliampere movement, calibrated in 1,000-cycle graduations from 0 to 20 kc.

A peak modulation indicator is provided in the form of a panel lamp that can be adjusted to flash on modulation peaks exceeding any predetermined modulation swing within the range of 5 to 20 kc. This is accomplished by the use of a thyratron tube as a switch for the panel lamp. The output of the audio amplifier is applied to the grid of the thyratron, and the firing point is controlled by a potentiometer that varies the bias on the tube. This bias control is a front panel adjustment, calibrated in terms of peak modulation levels. When a modulation peak exceeds the pre-determined firing point, the thyra-

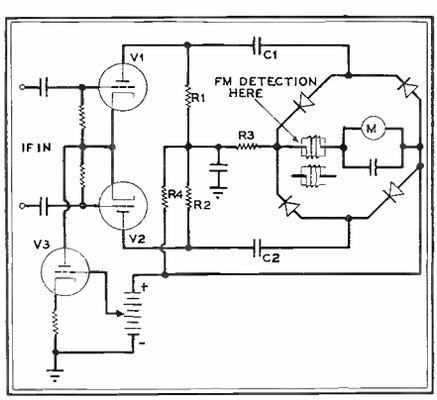


FIG. 7. SIMPLIFIED DIAGRAM OF DISCRIMINATOR

tron conducts and flashes the panel lamp in the plate circuit. An AC voltage is used as the plate supply for the thyratron, enabling the tube to stop conducting when the peak modulation drops to a level below the firing point.

The modulation polarity switch reverses the connections of the audio transformer in the discriminator circuit so that either positive or negative modulation swings can be monitored.

Audio Output:

An audio output for measurement or aural monitoring purposes is supplied through a cathode follower, providing isolation from the metering circuit, with or without a de-emphasis characteristic. Without de-emphasis, a modulation swing of 15 kc. produces an output level of approximately 6 volts into 10,000 ohms, with a signal-to-noise ratio of 46 db. This output can be very useful for making distortion measurements on a transmitter. The distortion inherent in the monitor is less than 0.5%. Used for aural monitoring only, the output can be provided with a de-emphasis characteristic of 6 db per octave between 300 cycles and 3 kc., in accordance with the proposed RMA standard for FM receivers. Where the output incorporates de-emphasis, the output level is approximately 3 volts for a 15-kc. modulation swing at low modulating frequencies.

Mechanical Design:

Mechanically, the instrument consists of two chassis fastened together and bolted

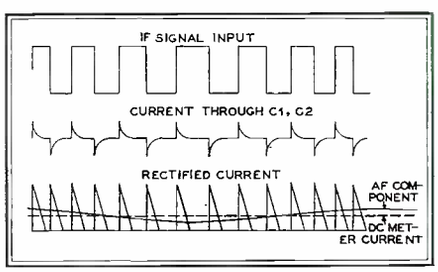


FIG. 8. WAVE FORMS IN DISCRIMINATOR CIRCUIT

to a 3/16-in. aluminum panel. The larger of the two chassis contains all the circuitry except the reference oscillator and mixer circuits. It is identical for both models of this monitor. In the case of the four-channel unit, the smaller chassis contains the channel selector switch, four crystal oven receptacles, and the components associated with the reference oscillator and mixer circuits. For the single-frequency unit, the smaller chassis contains one crystal oven receptacle and components of the reference oscillator and mixer circuits. The panel size for both models is 19 by 8¾ ins.

Operation:

The model 337B can be used to monitor the frequency of a transmitter of moderate power at a distance up to a few hundred feet, using a short wire for an antenna. With a more efficient antenna, the range can be extended to several miles.

The frequency selector switch must be set to cut in the proper crystal. To ascertain if the carrier level is adequate, it is only necessary to set the selector switch at the C.L. position. Any perceptible deflection of the modulation meter shows sufficient carrier signal level. Then, when the selector switch is turned to the USE position, frequency deviation and modulation can be read directly.

THE NEW ST. PAUL MOBILE RADIO SYSTEM

PART 1: A LINK RADIO INSTALLATION USING SELECTIVE CALLING — HOW IT IS USED BY THE POLICE DEPARTMENT — *By* ROBERT F. PETERSON*

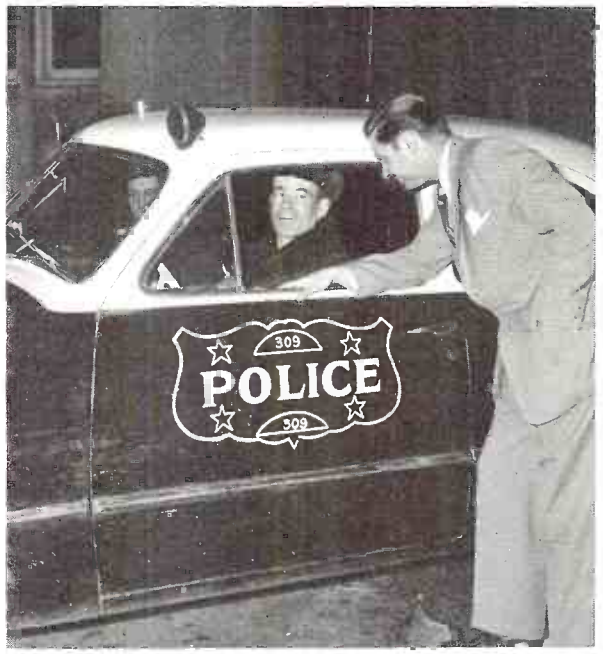


FIG. 1. RADIO-CONTROLLED SIGNAL LIGHT IS ABOVE CENTER OF WINDSHIELD. LINK ENGINEER BOB MORRISON STANDS BESIDE THE CRUISER

THE application of radio to the protection of lives and property can be divided into two phases. The first, concerned with mobile radio installation for patrol cars, is well established. The second phase of radio use, related to increasing the efficiency of departmental operation in the face of budget limitations, is still in its initial stage. It is to the second phase of police radio use that this discussion will be devoted.

Ratio of Service to Budgets:

In St. Paul, as is probably the case in every other city, greatly increased demands have been put upon our police department since the beginning of World War II. Not only has the public looked to us to perform added services, but we have had our share of increased crime and juvenile delinquency. Now, the development of long-range military aircraft makes us aware of the fact that our section of the United States is nearer to Russia than the east coast cities. Under the present state of national emergency, public safety problems, involving both police and fire protection, may become immeasurably complicated without warning.

Yet we must steer a course dictated on the one hand by our goal of increased protection, and on the other by strict economy. In the old days, new problems of policing could be met by added manpower, and needs for improving fire protion by the purchase of more modern apparatus. It is not necessary to remind municipal officials that present prices now make even replacements a serious problem.

FIG. 2. POLICE CHIEF CHARLES J. TIERNEY EXPECTS THAT ST. PAUL'S NEW COMMUNICATION SYSTEM WILL PROVE TO BE AN IMPORTANT ADDED SAFETY FACTOR IN CASE OF ENEMY AIR-RAID ATTACK

*Commissioner of Public Safety, Public Safety Building, St. Paul, Minn.

FIG. 3. THE AUTHOR BELIEVES FIRMLY THAT MODERN ENGINEERING PRACTICES CAN BE APPLIED AS SUCCESSFULLY TO POLICE AND FIRE DEPARTMENTS AS THEY ARE IN PRIVATE INDUSTRY

Today, with costs still climbing and budgets leveling off, outlay for new capital equipment can be justified only if it contributes to increased efficiency without adding appreciable upkeep expense or payroll. In short, to offset the higher salaries we must increase the effectiveness of each municipal employee by providing the most modern technical tools that science has made available. This calls for thorough, preliminary studies, however, because initial cost, amortization, and maintenance expense must be balanced carefully against the value of added service to the public.

Increased crime and juvenile delinquency require more foot-police contacts. There are greater demands on our radio patrol and emergency car services. We must anticipate the need of special fire protection in case of bombing attacks.

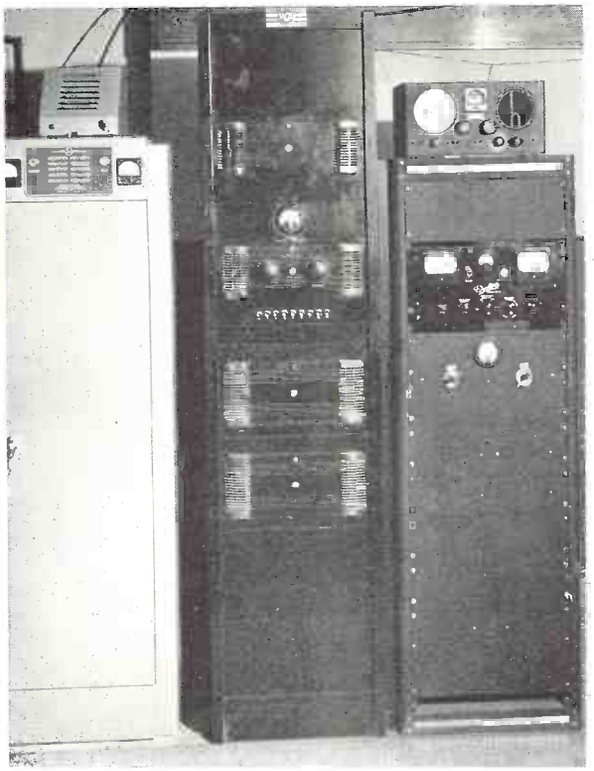


FIG. 7. THE STANDBY TRANSMITTER, PUBLIC ADDRESS AMPLIFIERS, AND MONITOR EQUIPMENT

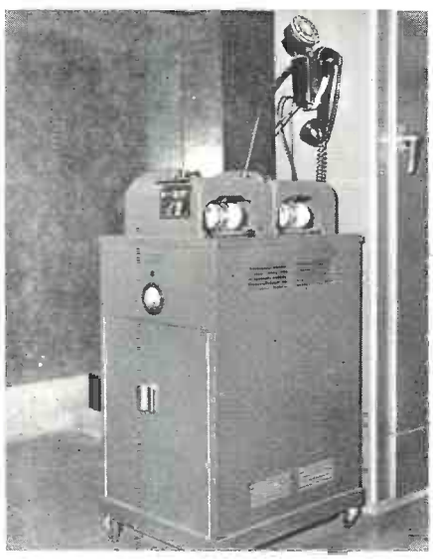


FIG. 8. ALL INCOMING AND OUTGOING CALLS ARE RECORDED ON THIS DICTAPHONE RECORDER

Obviously, more manpower is indicated, but in St. Paul our 40-hour week and limited budget make any substantial increase in personnel out of the question.

St. Paul Radio System:

Searching for a new approach to this familiar situation, we made a study of our city area, the departmental operation, and the organization structure. At the same time, we initiated an engineering survey of our radio communications. The net result of this work was the decision to revise our police radio facilities by installing:

1. New mobile units, capable of operating on two talk-back frequencies, with
2. Selective calling for each mobile unit.

And for the fire department:

1. Radio communication with selective calling from headquarters to each fire station, and
2. Mobile installations in department cars and fire apparatus.

This modernization plan has made the St. Paul radio system unique among municipal installations, giving us a degree of efficiency practically equivalent to doubling the number of police vehicles and the men assigned to them, and preparing our fire department to meet situations which may arise in case of an enemy air-raid.

Police Radio Dispatching:

In the new St. Paul radio system, police dispatching is planned around the use of Hammarlund Multi-gate[1] selective calling. This equipment was furnished as an integral part of our Link Radio headquarters installation and the mobile units.

[1]Editor's Note: Details of the Hammarlund selective calling equipment was described fully in "Privacy for Mobile Phones" by J. K. Kulansky, *FM-TV* Magazine December 1949 and January 1950.

It is used in this manner: When a driver leaves his car, he reports to the dispatcher and turns on his selective calling switch. Then, if the dispatcher wants to reach that man by radio, he presses a button on the control console corresponding to the car number. Instantly, a signal light is turned on at that car, or a horn or bell is actuated, depending on the particular equipment used in the car as a signal.

As soon as the driver returns to his car and calls in by radio, he presses a release button. This cuts off the signal light atop the car, or on the dash. Fig. 1 shows a signal light on one of our squad cars, mounted just above the center of the windshield.

All outgoing radio calls are handled through the telephone switchboard, Fig. 4, located in the Public Safety Building.

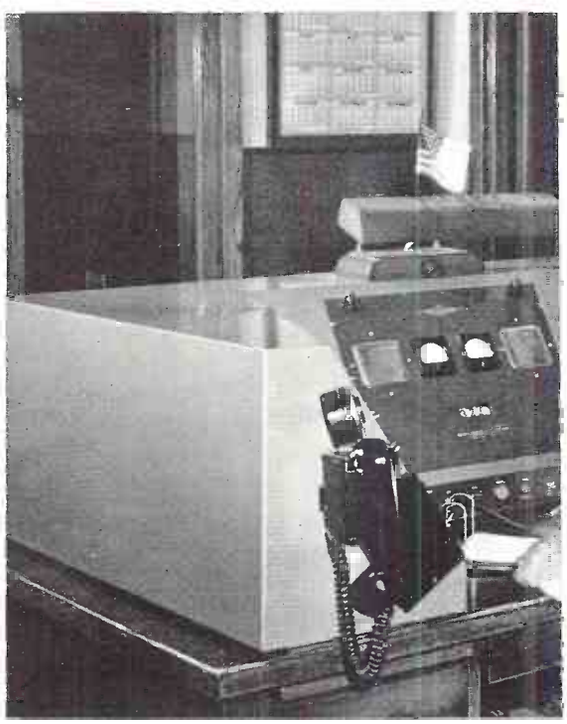


FIG. 5. SGT. HANS PETERSON AT THE SPECIAL LINK RADIO C SIGNALS ON MOBILE UNITS. LIGHTS AND SWITCHES ON TH

Messages to the radio dispatcher, Fig. 5, are transmitted to him from the board by Telautograph. His console has a selective-calling panel with 80 numbered buttons, representing a maximum of 80 receivers that can be called individually or, in the case of a general alarm, all at one time. At the left are 80 switches and numbered lights to show which receiving units are in service.

The radio operator has an identical console, Fig. 6, with the controls in parallel with those on the dispatcher's console. Thus, the operator can take over for the dispatcher whenever it is necessary, and assist him in handling traffic when the load is too heavy for one man. In addition, he has the overall re-

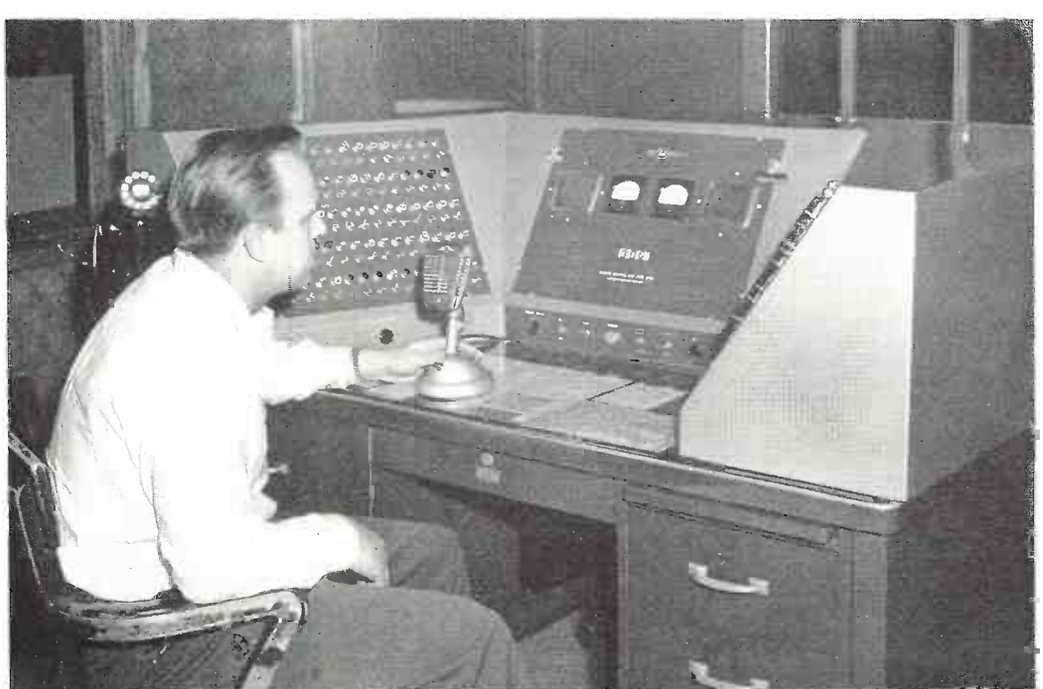


FIG. 6. RADIO OPERATOR ART TWEET HAS A DUPLICATE CONSOLE, IN PARALLEL WITH DISPATCHER'S CONSOLE. HE IS RESPONSIBLE FOR SYSTEM OPERATION, ASSISTS DISPATCHER IN RUSH HOURS

sponsibility for the functioning of the radio system.

All outgoing calls are handled on 159.09 mc. There is an emergency standby transmitter, Fig. 7, at the operating position and, adjacent to it, a Dictaphone dual recorder, Fig. 8. This device is turned on automatically to record incoming and outgoing messages. Fig. 7 also shows an RCA amplifier which operates speakers installed for the Director of Public Safety, Chief of Police, press room, Desk Sergeant, medical room, and in the detective division quarters. These speakers carry all radio messages unless they are turned down at their individual volume controls.

Frequency and modulation of the standby transmitter or of the main police and fire transmitters can be checked by the Doolittle monitor mounted in the

FIG. 4. CALLS COMING INTO POLICE HEADQUARTERS ARE HANDLED AT THIS SWITCHBOARD. MESSAGES TO THE RADIO DISPATCHER ARE TRANSMITTED BY THE TELAUTOGRAPH AT THE LEFT

ATCHER'S CONSOLE. THE BUTTONS AT HIS RIGHT OPERATE EFT BANK ARE USED TO SHOW WHICH CARS ARE IN SERVICE

right hand rack, Fig. 7. The communication receiver is used for monitoring.

The main police and fire transmitters and their antennas are installed at the First National Bank Building, and operated by remote control over telephone lines. This is also the receiving point for incoming messages. Fig. 9 shows the two transmitters. Monitor receivers, Fig. 10, are provided for use when either transmitter is being checked or adjusted.

Normally, the door of the transmitter room is locked. If it is opened, an alarm switch turns on a light at the dispatcher's console. The room is equipped with an automatic CO_2 fire-extinguisher system. If it is released, another switch operates a light to signal the dispatcher. Thus, protection is provided against both unlawful entry and fire.

A 1.5-kw. Onan emergency power unit is installed at the Public Safety Building. This provides power for the standby transmitter at police headquarters, the operating consoles, and lights required at the telephone switchboard and radio dispatching positions.

St. Paul's system also handles message traffic for the city of West St. Paul, and for the Sheriff's Department of Ramsay County. A special amplifier, bridged across the telephone line between the radio dispatcher and the remote transmitter and receiver at the First National Bank Building, is connected to the Sheriff's office. By means of speakers there, in coming and outgoing messages can be monitored at the Sheriff's private office, the Chief Criminal Deputy's office, and the Outside Patrol office.

FIG. 10. MONITOR RECEIVERS ARE SET UP ADJACENT TO THE POLICE AND FIRE TRANSMITTERS

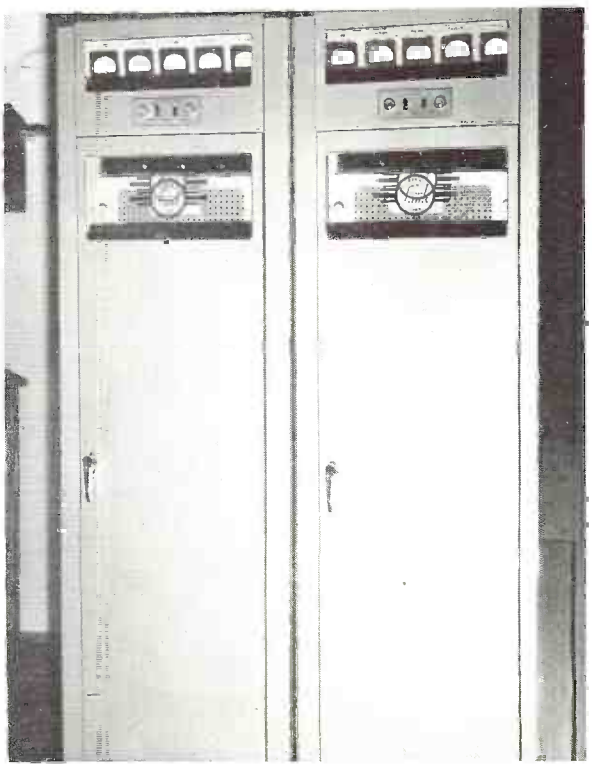
FIG. 9. THE MAIN POLICE AND FIRE TRANSMITTERS ARE INSTALLED IN A SMALL ROOM ON THE TOP FLOOR OF ST. PAUL'S HIGHEST BUILDING

Mobile Radio Operation:

The dual-frequency feature of our Link mobile units has increased our traffic capacity by a substantial amount. Under the old, single frequency setup, if a car wanted to reach headquarters with an emergency call at a time when the dispatcher was tied up with a routine report, it was necessary to wait until he completed his transmission.

Now, all mobile units operate normally on the primary frequency of 159.09, used also by the main transmitter. However, the dispatcher can be reached at any time by shifting the frequency of the mobile transmitter to 158.97 mc. When the dispatcher hears a call on the secondary frequency, he can interrupt a routine transmission to acknowledge an emergency call. This facility is particularly valuable during periods of heavy traffic.

The use of selective calling is the most important factor of our increased effi-



ciency. By this means, we have reduced the number of cars considered out of service during the absence of the drivers when they were performing duties on foot. There are many additional advantages in this system.

In St. Paul, we are able to assign only one man to each patrol car. Before the new system was installed, whenever it was necessary for an officer to leave his car, he reported to the dispatcher, who marked him out of service until he called back again. Now, when a man leaves his car, he is not out of service. If the dispatcher wants to recall him, he can do so simply by pushing the button corresponding to that car. Instantly, the signal light on the car is turned on, or a bell or horn is sounded.

Suppose a car is sent to the scene of an accident. The driver must leave his car to interview witnesses and make out a report. During that time, there might be a holdup just around the corner. Under the old system, that officer and his car would be out of service. Now, although he may not be within hearing distance of the speaker in his car, he can be recalled instantly by the selective calling signal.

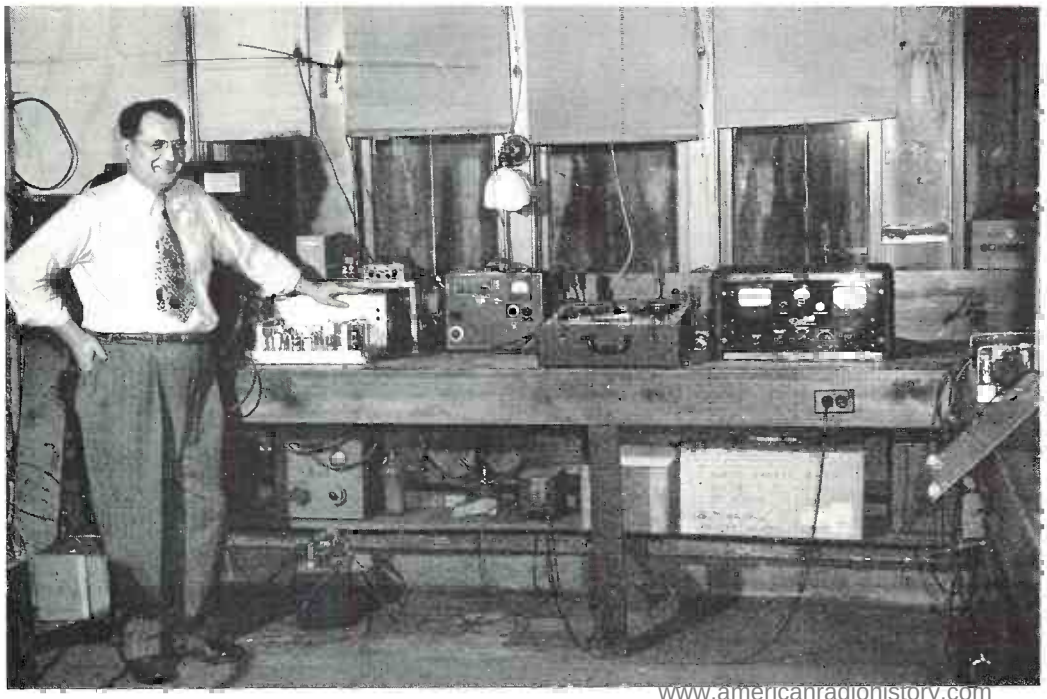
At night, when an officer leaves his car, he knows he must park it where he can keep an eye on the signal light. He may stop to question a pedestrian, try doors, or to make out a ticket for parking or speeding. In any case, the dispatcher can reach him without delay, and the officer is obliged to stay within reach of the signal.

Selective calling units have been installed on our three-wheelers. This makes them practically equivalent in service to a patrol car. A three-wheeler may be sent out on special traffic duty. The officer parks it at the curb, reports to the dispatcher, throws his selective calling switch, and takes up his traffic duty.

FIG. 11. SELECTIVE CALLING HAS PROVED TO BE VERY USEFUL FOR THE POLICE AMBULANCE, TOO

FIG. 12. AMBULANCE RADIO IS BEHIND THE SEAT

FIG. 13. SERVICE SHOP IS UNDER THE DIRECTION OF L. A. GINTHER, SUPERINTENDENT OF RADIO



Meanwhile, so far as availability for an emergency is concerned, he is still considered in service.

Selective calling has proved valuable to our detective division. They travel in pairs, but the system has a different use for them. Detectives' cars are equipped with special Ward antennas, mounted in front and designed to look as if they are intended for broadcast reception. The radio control box, selective calling switch, and handset are out of sight in the glove compartment. If a car is sent out to watch a particular spot, or to park among other cars where thieves may be operating, the sound of a loudspeaker, particularly in the summertime, would immediately identify the car. Now, if the dispatcher calls the car, the selective system merely lights a signal lamp on the dashboard. One of the detectives then leaves the car to answer from a public phone booth, or they drive off to a place where they will not be seen or heard using the car radio. As soon as the detective has answered a message, he presses the release button and the dash-light goes out.

No More Call Boxes:

In one respect, the St. Paul radio system has enabled us to make a substantial saving. We have done away with the use of police call-boxes.

The annual expense of maintaining wire circuits and repairs to the boxes amounts to a substantial sum. Now, we feel that the call-boxes do not serve a sufficiently useful purpose to justify their continued operation. The saving thus effected is considerably more than the added expense of maintenance for our selective calling system.

Radio Maintenance:

The idea of being able to reach any single vehicle in a police radio system by

(Concluded on page 38)

MID-VALLEY MICROWAVE RELAY

A MULTIPLEX RADIO RELAY WITH 36 REPEATERS, DESIGNED FOR THE OPERATIONAL REQUIREMENTS OF A 1,000-MILE PIPELINE — *By* DALE SAMUELSON*

EQUIPMENT developed for multiplexed microwave communication is finding wide application to long-distance radio relays, particularly for pipelines, power transmission systems, and railroads. The basic reasons are the low initial cost and subsequent maintenance, the flexibility of multiplex operation, freedom from interference, and reliability under adverse weather conditions.

Cost and Maintenance:

A typical example is the 1,000-mile Motorola relay system, operated by the Mid-Valley Pipeline Company, and jointly owned by the Standard Oil Company of Ohio, and the Sun Oil Company.

While the cost of installing wire lines on poles varies widely according to the terrain, it is obvious that the initial investment in construction and equipment would have totaled many times that of the 36 microwave repeater stations required for this system.

Even more impressive is the saving in maintenance expense. Wire lines may fail at any point along their length, and trouble seems to develop most frequently in the most inaccessible spots. In the case of a severe storm, long lengths of line may be put out of service, or damaged at intervals by falling trees. Thus emergency repair crews must be available at all times, stationed at points close enough that they can reach any part of the line quickly. Still, wind or sleet can do damage that may take several days to remedy.

Microwave relay stations, on the other hand, can be installed at points of ready access, and failures are localized at these installations. No intermediate faults can ever occur.

General Description:

The Mid-Valley system to be described was designed by Motorola, in conjunction with C. B. Lester of Sohio, and Charles Burgess of Sun Oil. The cost was about $800,000.

Extending from Longview, Texas, to Lima, Ohio, the relay follows the route of the pipeline indicated in Fig. 1. There are 36 repeater stations spaced 14 to 37 miles apart.

This system carries:

1. Two voice-frequency circuits assigned to party-line dial phones.
2. Three voice-frequency circuits assigned to private-line dial phones,
3. One party-line teletype, and
4. One circuit for drop-off communication with Mid-Valley cars and trucks equipped for 2-way radio.

These facilities provide the communication required between the pipeline terminals and between major pumping stations along the route. The status of the entire flow, including information on volume, pressure, and delivery rate, can thus be made known and coordinated from the control points. If it is necessary to change the rate of flow, instructions can be carried from any point over the

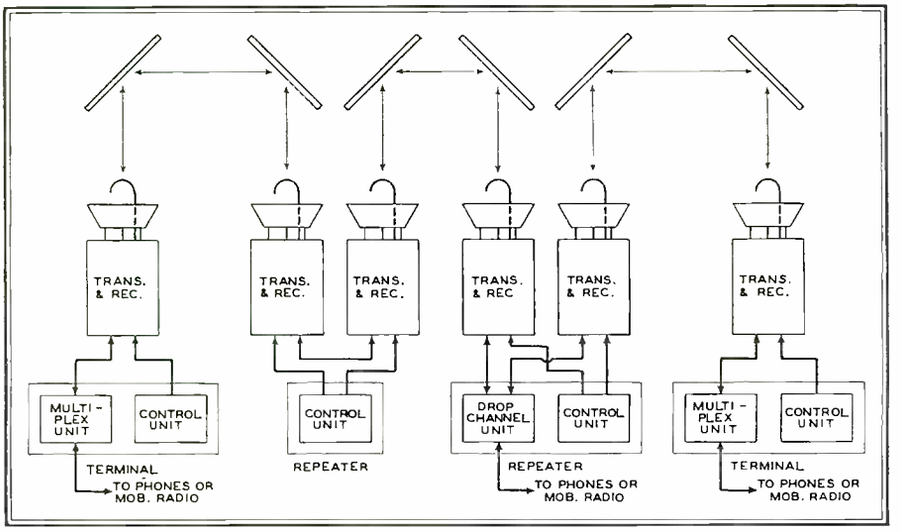


FIG. 2. OPERATING PLAN OF THE TERMINAL AND REPEATER STATIONS IN THE MICROWAVE RELAY

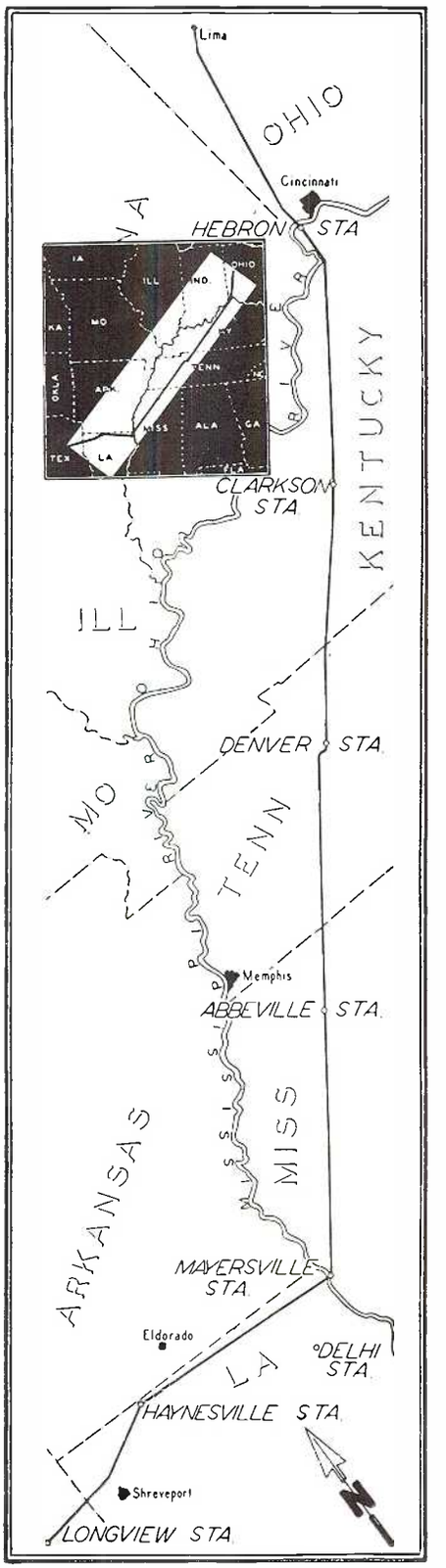


FIG. 1. THE MULTIPLEX RELAY SYSTEM FOLLOWS THE PATH OF THE 1,000-MILE MID-VALLEY PIPELINE FROM LONGVIEW, TEXAS TO LIMA, OHIO

*Communication & Electronics Division, Motorola, Inc., 4545 Augusta Boulevard, Chicago 51, Ill.

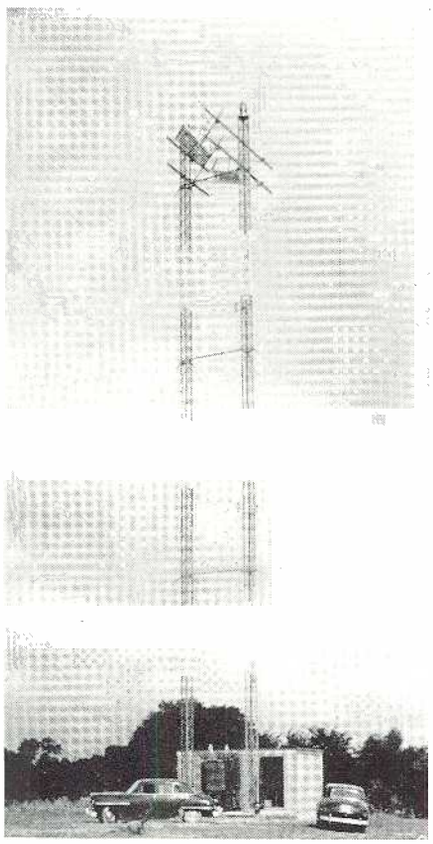


FIG. 3. A TYPICAL REPEATER STATION

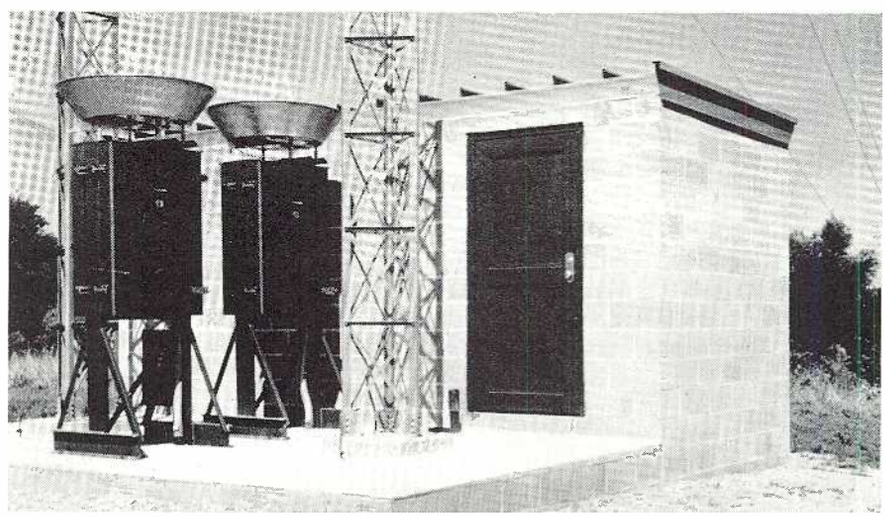


FIG 4. CLOSEUP OF THE OUTDOOR EQUIPMENT CABINETS AND THE PARABOLOIDS

been oriented, it requires no further adjustment. The microwave beam has a width of 3½°. Fig. 5 shows the elements of the ground installation.

Each transmitter and receiver housing, of weatherproof steel construction, has a waveguide horn and a 40-in. paraboloid reflector. Water drains are provided for each reflector, as well as heating elements for melting ice. Associated communication and control circuits are set up inside the station building.

There is a VHF transmitter and receiver at each station, operated over the relay system, for communication with mobile units. For this purpose, the system is divided into 7 sections, of which any one or more can be activated simultaneously.

entire length of the radio relay system.

Fig. 2 indicates the composition of the relay stations, of which that at Hebron, Ky., Fig. 3, is a typical example. Fig. 4 is a close-up view. At each point, signals are received, amplified, and re-transmitted. The passive tower-top reflector is a sheet of reinforced metal, perforated to reduce wind resistance. It merely acts to reflect signals, arriving in the horizontal plane, down to the ground-level installation, or to reflect signals directed upward in a horizontal plane, toward the next repeater. No electrical connection is made to the reflector and, once it has

Subcarrier Multiplex:

Motorola microwave multiplex equipment is designed for operation in the band from 6,575 to 6,875 mc. The Mid-Valley system is operated on a 10-mc. band, employing double-FM subcarrier multiplexing. This method was selected in preference to the pulse system because it affords a higher signal-to-noise ratio. Moreover, the construction of the subcarrier transmitters and receivers is relatively simple, party-line usage is flexible, channels can be dropped or reinserted with ease, and the cost of the equipment is comparatively low.

In this double-FM system, each voice-channel input frequency modulates an individual subcarrier transmitter in the 120-kc. to 1-mc. range. The subcarrier transmitters are of plug-in design, employing two 6SL7 double triodes. One triode is a voice limiter, the second is an oscillator, the third a frequency modulator, and the fourth a cathode follower.

The outputs of the subcarrier transmitters are fed to a klystron to produce the modulated carrier, operating on ±5-mc. swing for 100% modulation.

The microwave receiver, equipped with a discriminator, recovers the sub-carrier frequencies. This broad-band signal is applied to modulate the associated repeater transmitter directly, or it can be applied to subcarrier receivers

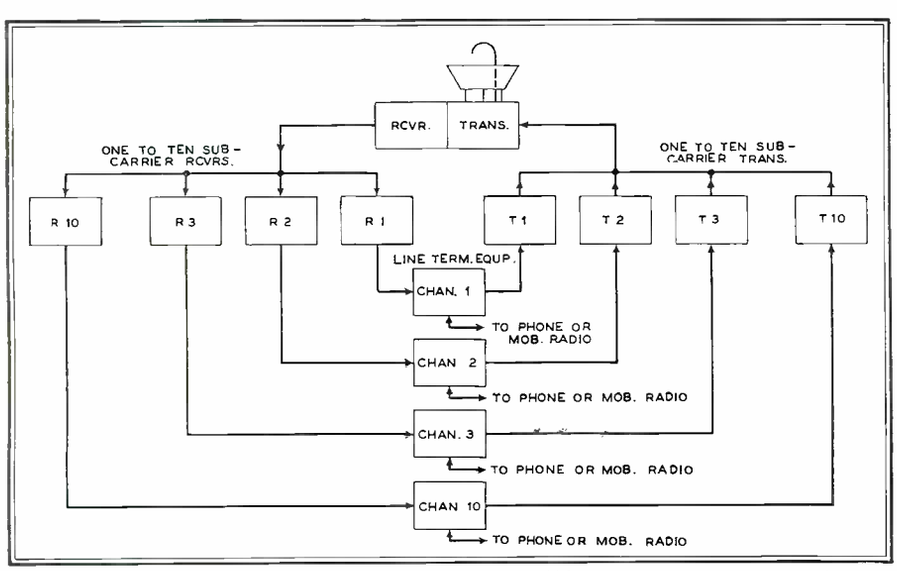


FIG. 5. TRANSMITTER-RECEIVER REPEATING UNIT AND THE ASSOCIATED CHANNELIZING EQUIPMENT

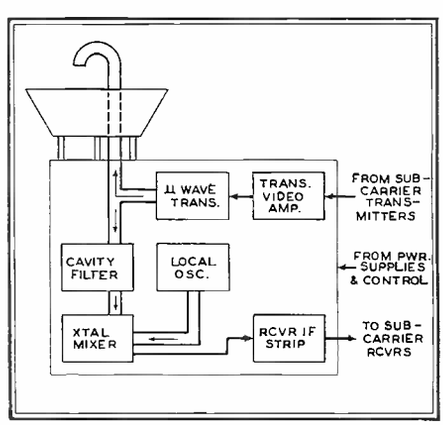
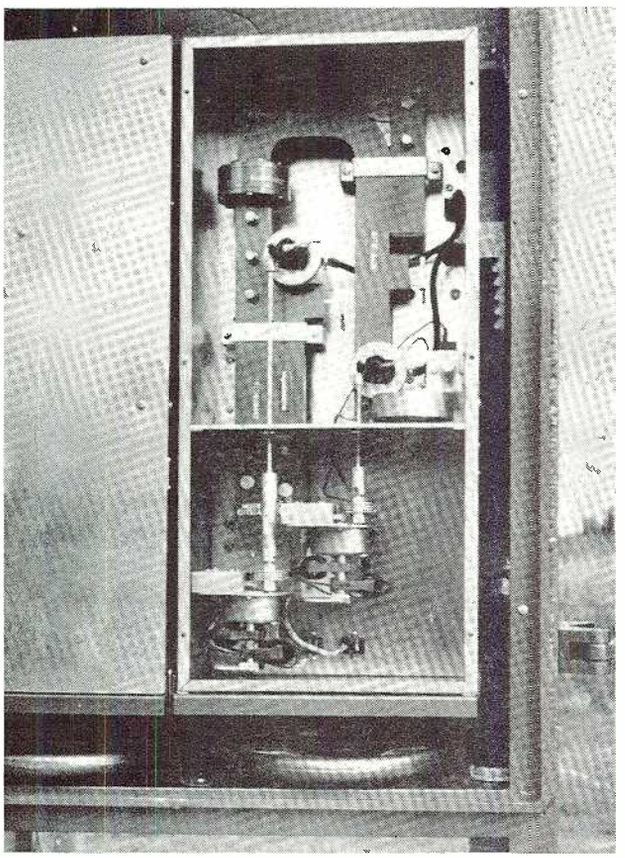


FIG. 6. KLYSTRON TUBES ARE EMPLOYED FOR THE MICROWAVE TRANSMITTER AND THE OSCILLATOR



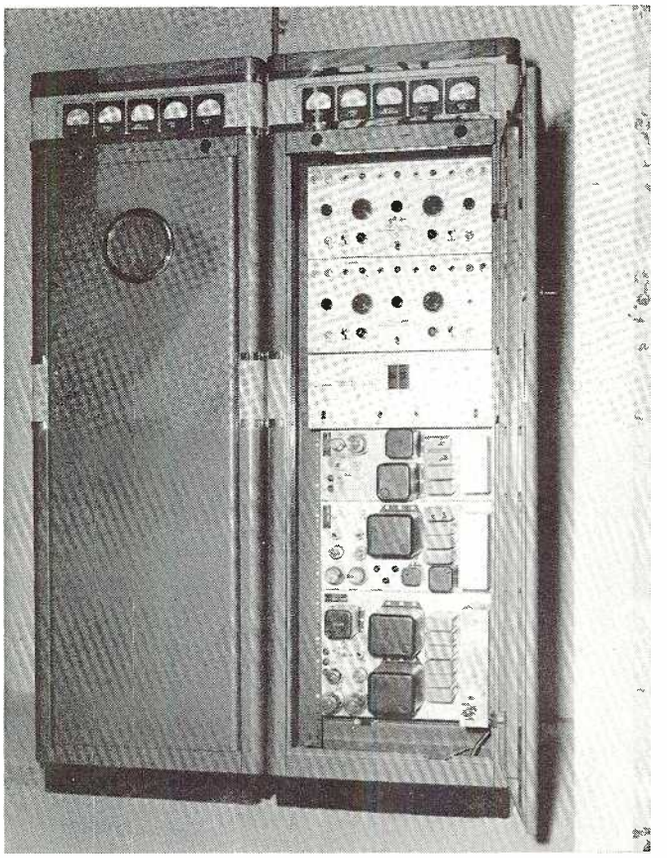


FIG. 7. COVER REMOVED FROM STANDY UNIT IN THE OUTDOOR CABINET FIG. 8. THIS EQUIPMENT IS INSTALLED INSIDE THE BUILDING

at a terminal station for complete audio detection. The subcarrier receivers employ conventional limiters and discriminators for recovering the voice frequencies. Distortion and cross-modulation are held to −54 db or less.

Use of Klystrons:

Two .1-watt klystron tubes are used in the relay units, one in the transmitter, and one in the local oscillator, as shown in Fig. 6. The use of two klystrons simplified maintenance, and makes it unnecessary to maintain a constant relationship between the outgoing and incoming frequencies. Also, since it is possible to eliminate a number of other tubes, operating costs are reduced.

The self-modulating type 5976 klystron employed in the 6,700-mc. band has further advantages. It is low in cost, does not require a blower, has a zero temperature coefficient, and operates from a receiver-type power supply. A further saving is effected by driving both klystrons in parallel from a single power supply. Their life is excellent, and a weak tube ages slowly, showing early evidence of impending failure by reduced cathode current.

Automatic Standby:

Each transmitter and receiver cabinet, Fig. 4, contains a standby unit, as illustrated in Fig. 7. Separate power supplies are also furnished, with automatic switchover controls., as shown in Fig. 8.

Sensing circuits built into the equipment recognize the failure of any tube or component, and actuate the switchover to the standby gear. Thus, if a failure occurs, it causes only a momentary interruption of the service.

Operating Frequency:

The band of 6,575 to 6,875 mc. was selected for Motorola microwave equipment as a result of extensive field tests and a lengthy analysis of recent propagation studies, particularly those conducted by the Federal agencies.

Attenuation due to rainfall, snow, and fog is summarized in Fig. 9. The 6,575- to 6,875-mc. band occupies a favorable position in this respect, as indicated by the shaded block.

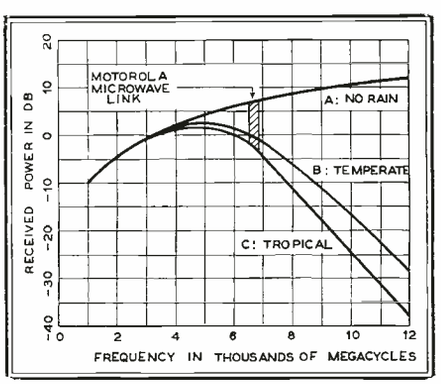


FIG. 9. ATTENUATION DUE TO RAIN, SNOW, FOG

It was necessary to select a frequency band sufficiently high to permit the use of high-gain antennas adaptable to efficient de-icing, and sufficiently directive to be relatively free from mutual interference effects from nearby stations. This indicated a band above 3,000 mc.

Radio frequencies in the 6,700-mc. region can be conducted by rigid waveguides, while VHF frequencies require coaxial conductors. If waveguides are used, frequencies above 5,000 mc. are preferred for reasons of economy. The wave-guides in this equipment have a cutoff at 4,300 mc., a major advantage because stray transmission on lower frequencies do not reach the receiver.

Finally, klystrons can be used most advantageously at 6,575 to 6,875 mc. Below 3,000 mc. klystrons are large and expensive. Above 10,000 mc., most RF oscillator tubes are unstable, and their inefficiency limits them to low power for continuous duty.

Additional Services:

The equipment described is designed for the use of telemetering and supervisory control circuits. With their addition, the positions of switches, signals, and valves, and the readings of all important meters at pumping stations can be displayed at any or all dispatch points. By employing remote controls, any number of valves, switches, or other unattended devices can be operated over the system.

NEW ELECTROLYTIC CAPACITORS

USE OF TANTALUM FOR ELECTRODES PROVIDES HIGHER LEAKAGE RESISTANCE, GREATLY REDUCED SIZE, AND LONGER LIFE — *By* M. WHITEHEAD*

TO meet the need for miniaturized equipment, it is frequently necessary to provide capacitance of the order of several microfarads in a very small space. Offering by far the most capacitance for their size, and the lowest cost per microfarad, are electrolytic capacitors. Electrolytic capacitors of the aluminum type, which have been commercially available, are not considered sufficiently reliable for many Bell System uses. Now, through the use of tantalum instead of aluminum as the electrode metal, these limitations are in a large measure removed. In addition, tantalum provides a further reduction in size, as illustrated by Fig. 1. This shows the comparative volumes of various types of capacitors having the same electrical rating.

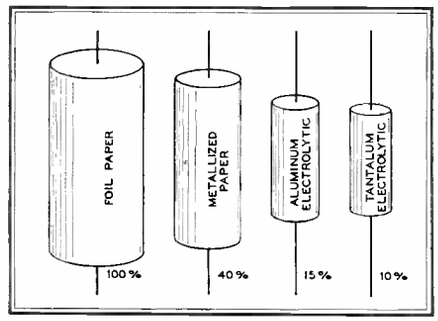


FIG. 1. COMPARATIVE SIZES FOR SAME CAPACITY

The dielectric in an electrolytic capacitor consists of an extremely thin oxide film formed electrolytically on the surface of the metal electrode. The electrolyte conductively connects the opposite side of the film to a second electrode which may be a foil or the container. The electrolyte also supplies oxygen as needed during operation, to maintain the insulating properties of the oxide layer.

The thickness of the film is a linear function of the voltage at which it is formed and is of the order of 10^{-7} cm. per volt. It is the extreme thinness of the dielectric film which permits the realization of large capacitances in small physical sizes. Because of its asymmetric resistance property, an electrolytic capacitor conducts current more freely in one direction than the other and is therefore essentially a polarized device. However, if the second electrode is also filmed with oxide it constitutes another capacitance in series with the first one. This non-polar construction is sometimes necessary where there are reversals of the applied potential polarity in service.

Tantalum, named after the Greek god Tantalus because of the tantalizing difficulties met in isolating this metal from its ore, has advantages in electrolytic capacitors for both chemical and mechanical reasons. From a chemical standpoint, tantalum resists attack from most acid reagents and it permits the use of electrolytes with operating characteristics superior to those which can be used with aluminum. From a mechanical standpoint, the properties of tantalum permit the fabrication of capacitors of smaller sizes than does aluminum.

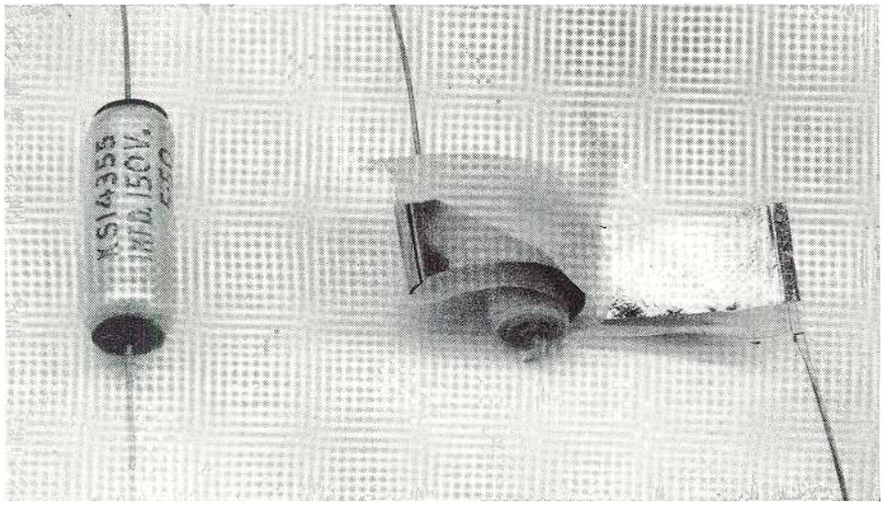


FIG. 2. THIS TANTALUM CAPACITOR IS MADE OF TWO ROLLED, PAPER-SEPARATED FOIL ELECTRODES

Construction Techniques:

Tantalum capacitors are made in two forms: one is of the conventional foil construction and the other is the sintered type. As shown in Fig. 2, the foil type is made by winding two paper-separated foil electrodes into a cylindrical unit. The absorbent paper serves essentially to contain the electrolyte and to prevent mechanical abrasion of the film during winding and use. For non-polar designs in this construction, both foils are filmed with oxide. In aluminum capacitors, the oxide-forming area of the foil is increased by chemical etching. So far, the tantalum capacitors employ foil only in its smooth rolled condition. But tantalum foil is inherently rougher, providing 10 to 20% more effective area than smooth aluminum. Also its oxide film is 50% higher in dielectric constant, and the metal can be used in thinner form. As a result, the present tantalum foil capacitors are about 30% smaller than their etched-aluminum counterparts. They are, however, larger than the sintered types for low-voltage ratings.

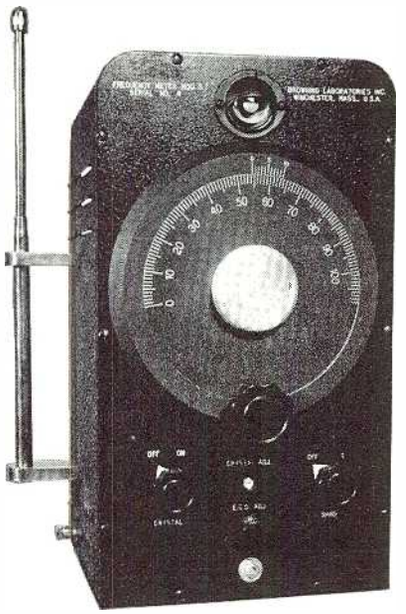
Tantalum is very amenable to powder-metallurgy techniques. Hence, for the sintered type shown in Fig. 3, the anode is made by pressing powdered tantalum into a compact shape and then sintering it in a vacuum furnace to weld the powdered particles. This results in a porous mass, in which a relatively large surface area is available for oxide film formation. The oxide-forming area in this structure is as much as 40 to 50 times that of a solid non-porous body of similar dimensions, which provides an outstanding reduction in size per unit of capacitance. The second electrode of this capacitor is usually the container.

Choice of Electrolyte:

One of the controlling considerations in the choice of electrolytes for these capacitors is the power factor. The power factor increases with the resistance of the mean conducting path from the anode surface through the electrolyte to the cathode. In the sintered type, the path from the anode to the container is relatively long because of the porous nature of the anode, and the required clearance between the anode and the container. To minimize the power factor for the sintered type, therefore, a higher-conductivity electrolyte is required than for the foil type where the close spacing of the electrode and the non-porous nature of the foil results in very much shorter conducting paths. Also, a highly fluid elec-

*Engineer, Transmission Apparatus Development Department, Bell Telephone Laboratories, Inc., 463 West Street, New York 14, N. Y. This article appeared originally in *Bell Laboratories Record*, October, 1950.

For Mobile Radio System Maintenance



Browning Frequency Meters for Mobile Services

MODEL S-4

Calibrated at any 1 to 5 points within the band of 1.5 to 70 mc. Hand-calibrated crystal control accurate to .0025 per cent as required by the FCC. So easy to use that any fixed or mobile transmitter can be checked in 60 seconds. Rugged construction, as illustrated, will withstand years of use. Built-in, regulated power supply for 110-115 volts AC or DC.

MODEL S-7

Calibrated at 1 or 2 points within the bands of 72 to 76 and/or 152 to 162 mc. For systems operating on either or both of the two bands indicated. Hand-calibrated crystal control accurate to .0025 per cent as required by the FCC. Similar in design and ease of operation to the model S-4 illustrated there. Built-in, regulated power supply operates on 110-115 volts AC or DC.

MODEL S-5

Calibrated at any 1 to 3 points within the band of 30 to 500 mc. This semi-portable meter, not illustrated, is maintained at an accuracy of .0025 per cent by the use of a temperature-controlled crystal and a temperature-compensated electron-coupled oscillator. Furnished in a steel case or for rack mounting. Front panel 8¾ by 19 ins. For use on 105-115 volts AC.

IMPORTANT INFORMATION

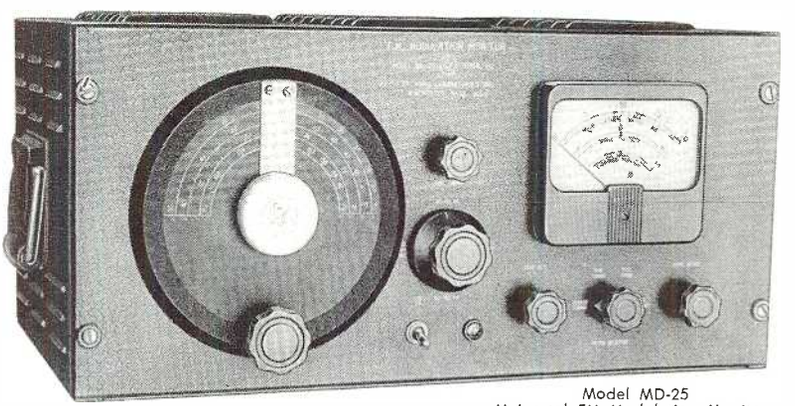
The accuracy of any BROWNING frequency meter can be checked in the field with WWV standard frequency signals, because the crystal frequencies employed are submultiples of WWV.

Browning Universal FM Modulation Monitor

The distinctive feature of the BROWNING model MD-25 FM Modulation Monitor is its universal coverage of all frequencies between 30 to 50 mc., 72 to 76 mc., and 152 to 162 mc. Consider the convenience and economy of such an instrument compared to those which can measure modulation only on one or two specific frequencies!

With the BROWNING model MD-25, you are certain of being able to make measurements at all frequencies required now in those bands, or additional frequencies you may encounter at any time in the future.

This is particularly important to radio maintenance organizations, for it is assurance that added customers can be served without the expense of buying more modulation monitors to check additional frequencies.



Model MD-25
Universal FM Modulation Monitor

And remember that the BROWNING model MD-25 represents the engineering skill and precision manufacture that have made BROWNING Frequency Meters the standard of the communication services since 1940. Before you buy any type of modulation monitor, send for information on the MD-25, and check its ease of operation, its flexibility, and the economy of all-band operation in a single instrument.

Send for your copies of the Technical Information Bulletins on these instruments, and delivery dates

BROWNING
LABORATORIES, INC.
WINCHESTER, MASS.
ENGINEERED FOR ENGINEERS

IN CANADA, ADDRESS:

Measurement Engineering, Ltd., Arnprior, Ont.

BROWNING LABORATORIES, Inc.
750 Main St., Winchester, Mass.

Please send me technical details and prices on the following Browning precision products:

☐ Model MD-25 Universal Modulation Monitor

☐ Frequency Meters, calibrated at the following frequencies

.....mc.....mc.....mc.....mc

Name .....

Address .....

Company Connection .....

trolyte is necessary to penetrate the pores of the sintered structure and realize the full capacitance available, whereas a glycol base electrolyte of higher viscosity can be used in the foil type.

The use of a high-conductivity electrolyte in the sintered capacitors imposes a voltage limitation which is dictated by the threshold potential at which sparking occurs at the oxide film. This potential depends on the type of ion present, its concentration, and its mobility. Electrolytes of lower ionic concentration and mobility and therefore of lower conductivity, like the glycol type, permit operation at higher voltages. For this reason, the foil type which can be used with low-conductivity glycol is employed for the higher operating voltages. The maximum safe operating potential of the sintered capacitors is about 70 volts with the aqueous solution of lithium choride in current use.

Containers for the two types of capacitors are distinctly different in function. In the foil type, the container is merely a housing for the capacitor, whereas in the sintered type the container is part of the electrical circuit. The inert nature of the glycol-base electrolyte used in the foil capacitors permits the use of a simple container of silver-plated copper tubing, crimped at each end onto a rubber stopper. For the sintered capacitors, the container is of drawn fine silver. This is used because of its resistance to chemical action from the more corrosive electrolyte. Silver wets well and provides low contact resistance with the electrolyte. Furthermore, it catalyzes the recombination of any pressure-creating hydrogen gas evolved through electrolysis at the cathode. To provide a non-polar version of the sintered capacitor, tantalum must be used for the container instead of silver.

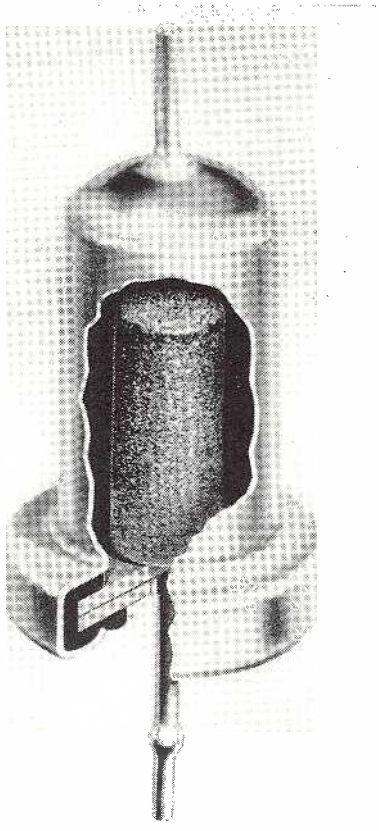


FIG. 3. SINTERED TYPE OF TANTALUM CAPACITOR

Operating Characteristics:

The tantalum capacitors, described herein, are of recent design on which development and life studies are still in progress. While some life-test data have been collected on representative samples, these data, at present, are inadequate to permit evaluating the full life expectancy. However, from the known properties of tantalum together with the indicated stability of the tantalum oxide film, it is expected that tantalum will endow electrolytic capacitors with a greater service life than can be obtained from the aluminum types.

One of the characteristics of electrolytic capacitors, which can be used as a figure of merit to indicate the completeness of the oxide film and its ability to withstand operating conditions for long periods, is the leakage resistance. The leakage resistance performance of tantalum capacitors compared with aluminum, with respect to the time period of the applied voltage, the magnitude of the voltage, and with respect to temperature, is shown in Fig. 4. The higher initial leakage resistances for tantalum are an indication of longer life expectancy and, moreover, the oxide film stability maintains this high order of leakage resistance both in operation and under idle conditions to a higher degree than with aluminum.

In idle equipment or in storage, electrolytic capacitors of all types undergo a decrease in DC leakage resistance. This is caused by diffusion of a polarizing gas layer and deterioration of the film at minute spots where metallic impurities are present on the surface of the base metal. The affected areas are too small to cause important changes in the AC capacitance or effective series resistance. Upon reapplication of voltage, this reduced leakage resistance permits relatively large leakage currents which, in the case of aluminum capacitors, may be so high as to cause destructive overheating before the film reforms. For this reason, the safe storage period for aluminum types is normally limited to about two years. The leakage resistance with tantalum is not only higher but, as illustrated in Fig. 5, it decreases less during idleness. Hence, the storage limitations necessary with aluminum capacitors are being disregarded.

In paper capacitors, impending failure of the dielectric under voltage is frequently foreshadowed by large decreases in the DC leakage resistance. This is not true of electrolytic capacitors, the failure of which is associated with the development of a high impedance rather than a short circuit. The behavior of the impedance is the best indication of aging effects leading to failure. Loss of capacitance and increase of effective series resistance are trends to be expected, and these are primarily a function of the stability of the electrolyte.

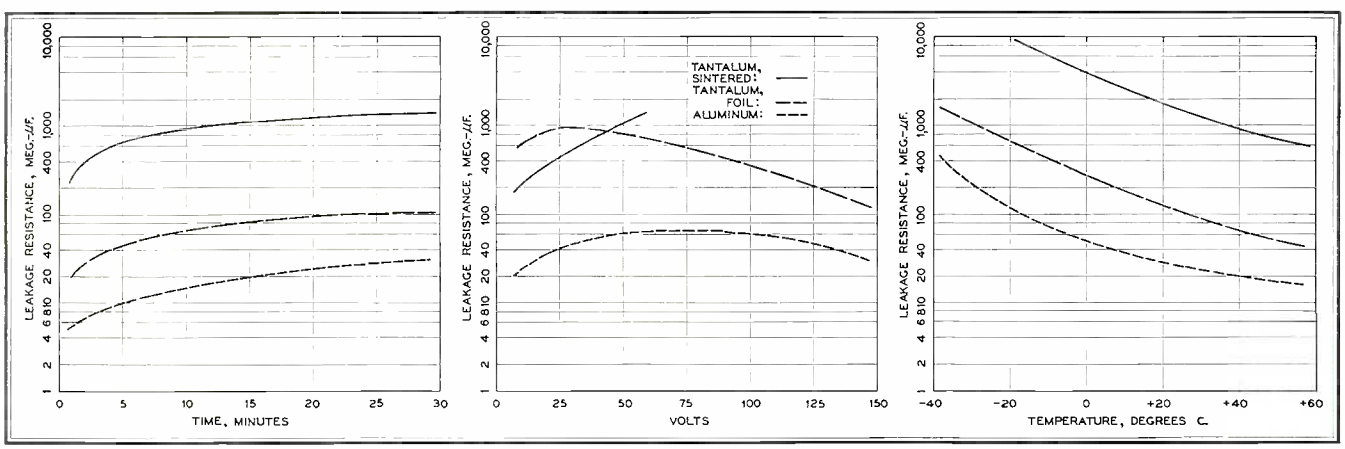


FIG. 4. COMPARATIVE CAPACITOR PERFORMANCE IS SHOWN BY PLOTTING LEAKAGE AGAINST TIME, APPLIED VOLTAGE, AND TEMPERATURE

How Long Is a Month?

Well, It's a Long, Long Time If You Lose Your

LICENSED RADIO OPERATOR

IF you are responsible for the operation of a radio communication system, you have probably checked the military status of your licensed operators. If you are satisfied that they are not subject to call, and that there is no possibility that they could be hired away by one of the many new systems going on the air every day, you are very fortunate indeed. You have nothing to worry about.

But if there's the slightest doubt in your mind, here is something that deserves your most thoughtful and immediate consideration:

The Demand Exeeds the Supply:

The demand for licensed operators has become so great during the past year that far exceeds the number of qualified men now available!

Consequently, if one of your operators resigns, or is called to military duty, you will probably not be able to replace him. To meet that situation, you will probably have to pick a man who is willing to take a study course so that he can prepare to pass the FCC radio operator examination. Only then will he have the license required by the Commission of any man who installs and services radio communication transmitters.

How long will it take to complete such a course of study? Well, that depends on the man's previous training and experience.

At the Cleveland Institute of Radio Electronics, we find that many of our students require only 10 weeks. Some take 4 or 5 months. The principal factor is the amount of time a man can study each day.

Although we are graduating more licensed operators than any similar school, an increasing number of our students have jobs awaiting them even before they enroll.

In years past, we have been able to fill requests from communication systems for operators with reasonable promptness. But that is no longer possible. Today, finding a man who is available where he is needed is largely a matter of luck. It isn't a matter of the salary you want to pay, but of finding an operator at any price!

Recognizing these new conditions, the FCC is now cooperating by giving quarterly operator examinations at 31 cities, semi-annual examinations at 23 cities, and annual examinations at 7 cities. In addition, examinations are given daily at its 32 offices.

How to Anticipate Emergencies:

The situation is now critical to the point that we strongly urge company executives and public officials to anticipate such emergencies without delay. Here is our recommendation:

Select a man, preferably within your organization, to be trained as a 2nd class radiophone operator, in accordance with FCC requirements. He should be at least a high school graduate who received high marks in mathematics and physics, and who has had radio experience as an experimenter, amateur operator, serviceman, or with the use of military radio equipment.

Then enter him for the CIRE correspondence course in Radio Communication. On request, we will send you our enrollment application. If we accept his qualifications, the Institute will guarantee that, upon completion of the course, should he fail to pass the FCC examination for 2nd class radiophone operator, he will be given further, special instruction without any extra charge, until he does pass. Our records show, however, that CIRE students are almost invariably successful the first time. Many pass the examination before they complete the course.

Time Required, and Cost of Training:

About 200 hours of study are required. Many companies are now putting their men on half-time schedules so that they can complete the course within 10 weeks. The total cost of the course is $89.75, payable in advance. This amount is subject to refund in full in case of any dissatisfaction within five days after receipt of the first group of study lessons. Currently, most employers are standing the full expense as an inducement to the men they select for training. Others are paying one-half, and making a small weekly payroll deduction to cover the balance. In either case, the cost is a minor matter compared to the security of having a licensed operator available to meet any emergency. The important thing is to act now to protect your radio system against being closed down before an emergency situation arises. The coupon below is provided for your convenience.

Cleveland Institute of Radio Electronics
Special Attention: Desk No. 4
4900 Euclid Ave., Cleveland, 3, Ohio

Please forward enrollment application for CIRE Course, preparatory for FCC 2nd class radiophone operator examination. If you accept the qualifications of the man we select, we will promptly forward check for $89.75 to cover the total cost of the Course, subject to the guarantee that:

1. Our remittance will be refunded in full if, for any reason, within 5 days after receipt of the first group of study material, we are not completely satisfied.

2. If the man we select does not pass the FCC examination after completing the course, CIRE will provide additional instruction, without further charge, until he does pass the FCC examination.

Name .....

Company .....

Address .....

.....

Note: This CIRE Course is approved for Veteran Training under GI Bill.

Open-circuit failures from uncontrollable corrosion of the base metal, as frequently experienced in aluminum capacitors, are non-existent in tantalum capacitors because of the immunity of this metal to common contaminants.

The relatively high power factor of electrolytic capacitors limits their use to low-voltage AC applications since, at higher values, internal dissipation overheats the capacitors and sometimes vaporizes the electrolyte, creating dangerous internal pressures. This high power factor also makes them unsuitable for most tuning circuits. The power factor of the tantalum capacitor is not improved importantly compared to aluminum. A typical curve of the power factor as a function of frequency, for tantalum capacitors of the ratings covered by this article, is given in Fig. 6.

Due to the wide swing in the conductivity of the electrolyte with temperature, electrolytic capacitors exhibit a large increase in power factor at low temperatures, the predominant effect of temperature being observed in the effective series resistance component. Characteristic curves of the power factor and the change of capacitance with temperature are shown in Fig. 7. The tantalum capacitor has a better temperature coefficient than aluminum, and can be used as low as -60°C., whereas the usable range of the aluminum type is limited to about -40°C. As with aluminum, the temperature coefficient of capacitance increases with increasing frequency.

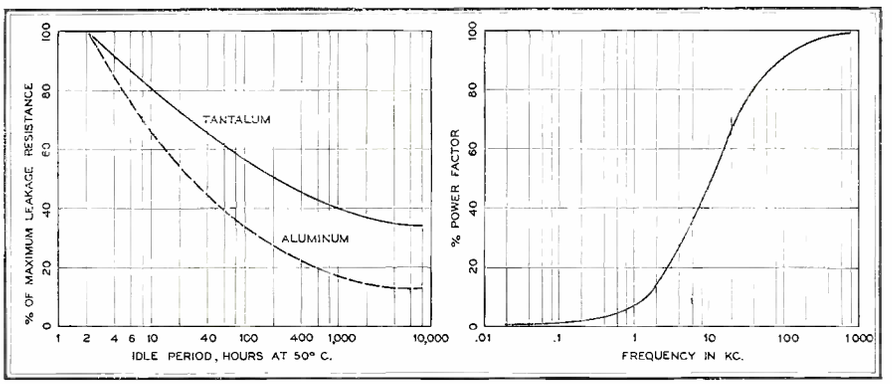


FIG. 5. LEAKAGE RESISTANCE VS. IDLE TIME. FIG. 6. POWER FACTOR VS. FREQUENCY FOR TANTALUM

Applications:

So far, tantalum capacitors of relatively low capacitance values have been used principally as substitutes for paper capacitors, where small size is an advantage from the standpoint of equipment layout. It is expected that a large field of use for tantalum capacitors will be in capacitance ratings similar to those of conventional paper capacitors. Three ratings are in commercial production for use in the Type N system. One is of the sintered construction, 4 mfd. at 60 volts polar; and two are of the foil construction, 1 mfd. at 150 volts polar and 1 mfd. at 150 volts non-polar.

The sintered capacitor is manufactured by the Fansteel Metallurgical Corporation and the foil type by the General Electric Company. Considerable laboratory and manufacturing development effort has been undertaken by both Bell Laboratories and these suppliers in making the capacitors useful and practicable components, and further work is in progress to develop them for other uses in the telephone system.

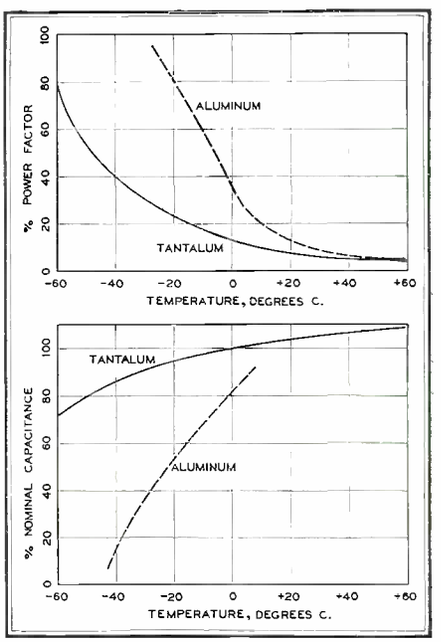
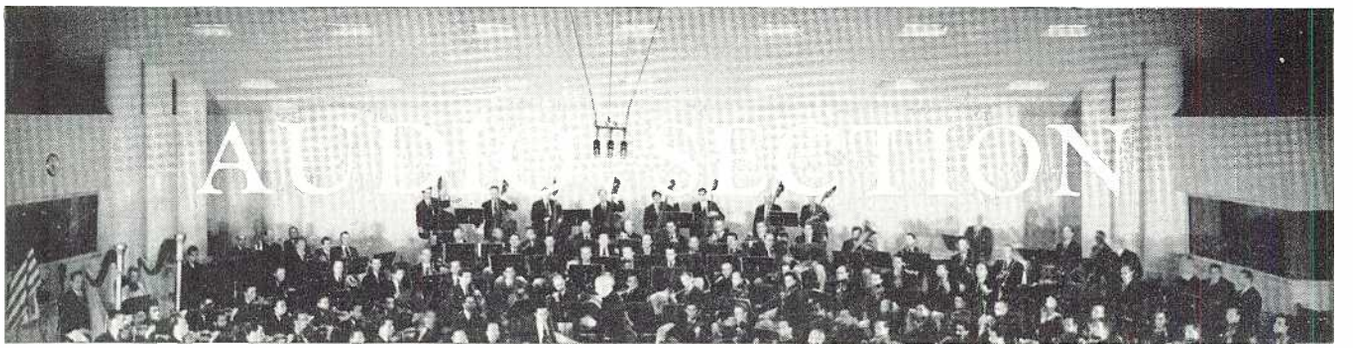


FIG. 7. POWER FACTOR & CAPACITANCE OF ALUMINUM AND TANTALUM TYPES VS. TEMPERATURE

Editor's Note: According to the January issue of *Technical Data Digest*, published by the U. S. Central Air Documents Office, tantalum capacitors developed by P. R. Mallory Company under an Air Force contract have an estimated shelf life of 5 to 8 years. Tests show less than 15% loss of capacitance at -60°C. These units will soon undergo standardization, and it is expected that they will be used widely for radar, communication, and navigation sets.



THE FAS AUDIO SYSTEM

PART 4: HOW TO DESIGN AND BUILD AN 8-FT. AIR-COUPLER — EXPERIMENTS WITH 15-IN. SPEAKERS FOR HIGH-VOLUME OUTPUT — *By* CHARLES FOWLER

AMONG all the questions raised in the hundreds of letters we have received since the beginning of this series of articles on the FAS system, two predominate: 1) how best can I use my 15-in. woofer, and 2) what happens if I use a longer Air-coupler?

These are very logical lines of exploration, and they go hand in hand. Using 12-in. speakers, the FAS system was brought to such a point of perfection that it has created unprecedented acclaim among audio enthusiasts. It was to be expected that even more startling results could be achieved by employing bigger speakers and bigger Air-couplers.

We feel that we have made very definite progress with larger speakers and Air-couplers but, as with all audio problems, there is far more to it than meets the eye (or ear)! The number of variables are infinite, and the engineering charts and mathematical formulae provide little clue as to what will actually happen. Therefore, we advise, that if you want to put an FAS system into operation with certainty as to the results you will obtain, you adhere strictly to the specifications outlined previously. But if you want to experiment with the system and to take part in its development, this article will provide definite direction to your work, and it may well provide the final answer.

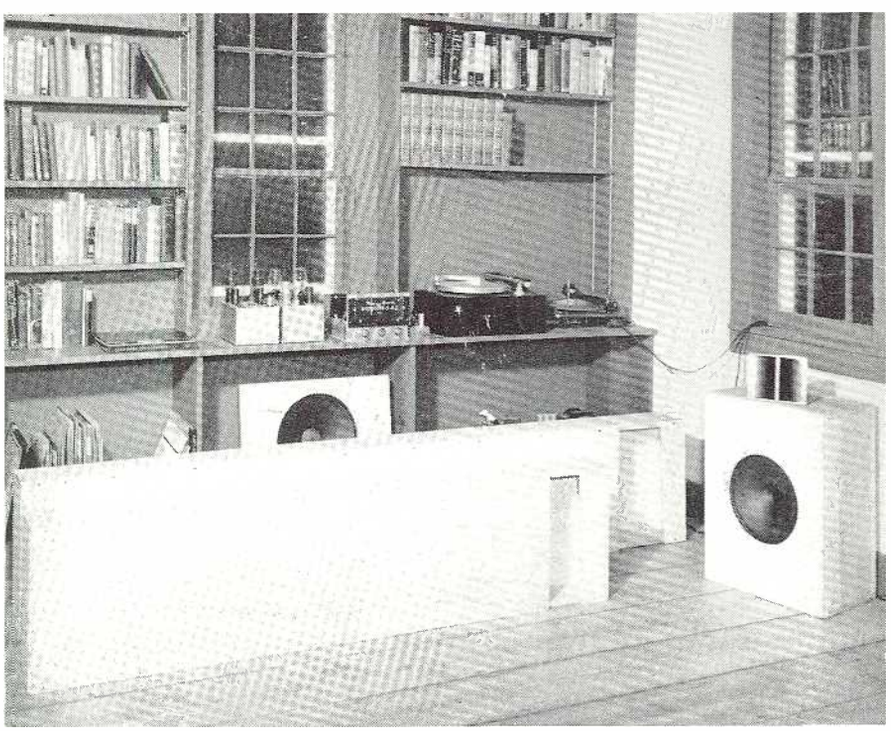


FIG. 1. TEMPORARY ARRANGEMENT OF 6- AND 8-FT. AIR-COUPLERS SHOWS COMPARATIVE SIZE

Purpose of the Experiments:

Stated as directly as possible, the purpose of our most recent effort has been to answer the question: what happens if a 15-in. speaker is used on an Air-coupler type of enclosure? One would expect greater sound-power-output. The larger cone should drive the body of air in the coupler more powerfully, thus producing more sound with the same setting of the volume control, but it didn't work that way, exactly. Hence our experiments developed into an effort to determine as many as possible of the factors influencing optimum performance of 15-in. speakers in the Air-coupler type of enclosure.

Equipment Used:

It would be well at this point to count off the various pieces of equipment used for these tests. Such a list will indicate the number of variables which can influence any custom installation of an FAS system, and these variables all interact to affect the final result.

AMPLIFIERS: Our standard of comparison was the original FAS amplifier described in the October issue of this Magazine, but for these tests we used a McIntosh 50W-2 and the Peerless version of the Williamson. The McIntosh is one of the best high-fidelity amplifiers, and its plug-in type of output connection facilitated switching from 8- to 16-ohm impedance taps.

SPEAKERS: Although a considerable number of speakers was available for these experiments, we limited the number of variables by using only three for the woofer in the Air-coupler, a Jensen P15-NL 15-in., our standard Altec 600-B, and a GE-S1201D. Little attention was paid to the middle and high side; a Jensen HNP-51 coaxial speaker of 16 ohms im-

pedance balanced the 15-in. Jensen, and the 12-in. GE and Altec speakers, used alternately as woofers and middle-range, balanced one another at 8 ohms. A University tweeter was used very successfully to carry the extreme highs.

AIR-COUPLERS: When we first began to consider these experiments, we drew up a plan for an Air-coupler 8 ft. long, with front and back panels divided into sections to permit varying the location of either the speaker or port, or both. We then sent off to our local cabinet maker a bill of goods, brought back the pieces of ¾-in. plywood, and nonchalantly sat down to begin our tests. After screwing and unscrewing panels for several evenings, we began to wonder just how many possible combinations and arrangements could be made with the given pieces of lumber. To rest our blistered hands for a moment, we stopped to figure it out. When we got up to 960 different dimensions of Air-couplers, all from a relatively few pieces of wood, we stopped figuring! This figure should, Heaven forbid, be further multiplied by the number of speakers available for testing on each of the 960 combinations! This explains all too clearly why the task of securing optimum performance is a long process.

The photograph, Fig. 1, shows most of this equipment. The 6- and 8-ft. Air-couplers were laid side by side to indicate their relative size. The Altec 600-B on the 6-ft. Air-coupler is matched with the 12-in. GE in the small cabinet. The University tweeter carries the extreme highs. The 15-in. Jensen woofer is on the 8-ft. Air-coupler; note the 7-in. port on this coupler. Behind the couplers is the Jensen coaxial speaker, matching its 16-ohm counterpart on the Air-coupler. On the shelf is the McIntosh amplifier, the new Browning RV-10A, and two turntables. The turntable on the left is equipped with a Pickering cartridge; the Webster has GE reluctance cartridges for 78- and 33-RPM records.

Importance of Variables:

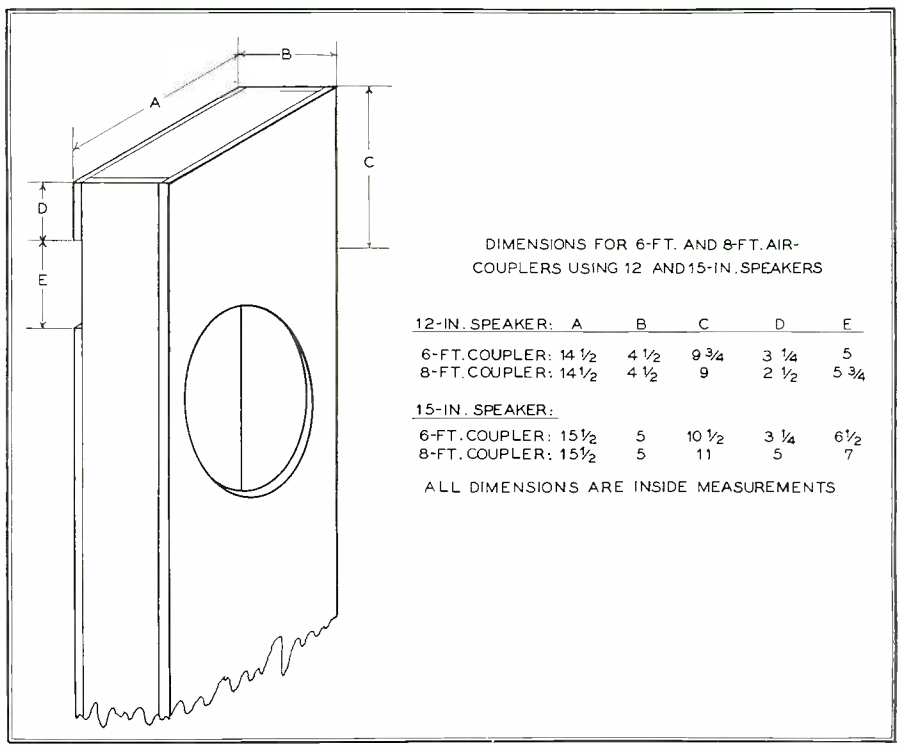
As the foregoing figures indicate only too well, the primary variable is the size and shape of the Air-coupler. And sometimes even a slight variation makes a marked difference. In one test, for example, shifting the speaker 4 ins. made a decided improvement in overall tone response. But other variables also affect overall performance of the FAS system.

First, two different amplifiers will produce different results with the same speaker; conversely, different speakers with the same amplifier produce quite different results. For instance, in a test conducted some time ago, we found that two speakers were almost indistinguishable (aurally) when checked with one amplifier; when a different type of amplifier was used, one speaker was far superior to the other.

Second, of course, is the speaker itself. The minute we move from a 12- to a 15-in speaker, we lose comparability . . . even if the speakers are of identical make. Speaker resonance, cone compliance, and overall efficiency are three criteria which change radically. So, in a very real way, using a 15-in. speaker instead of a 12-in. model is the same as starting from scratch. With a 12-in. speaker in a 6-ft. Air-coupler, we have already achieved a balance of speaker and coupler characteristics which approach optimum performance. The problem ahead, as we started these experiments with 15-in. models was to establish a new balance between the speaker and the Air-coupler characteristics.

The construction of the coupler itself introduces another variable. Just as the tone of a musical instrument depends on minute variations in its materials and construction, so, too, the reproducing characteristics of the coupler change with its overall size, the way it is built, and the material of its construction, as well as its "architectural" specifications.

Finally, the most deceptive variable of all is the ear. We have a great deal of respect for the highly technical measurements which can be made of reproducing equipment and systems. But a flat curve means nothing if it does not please the ear. As a matter of fact, a flat curve at low volume levels is very likely not to please the ear! We insist on bearing in mind a comment by Briggs[1] on a chart showing the results of one of his experiments on crossover networks: "In spite of the fact that the chart looks as if the patient were just recovering from double pneumonia, the set-up sounds all right." For that reason, there are no charts and graphs in any of these articles. They are important as guideposts to small changes taking place when equipment or sizes are varied, but the important thing is that it must "sound all right."



DIMENSIONS FOR 6-FT. AND 8-FT. AIR-COUPLERS USING 12 AND 15-IN. SPEAKERS

12-IN. SPEAKER:	A	B	C	D	E
6-FT. COUPLER:	14 ½	4 ½	9 ¾	3 ¼	5
8-FT. COUPLER:	14 ½	4 ½	9	2 ½	5 ¾
15-IN. SPEAKER:					
6-FT. COUPLER:	15 ½	5	10 ½	3 ¼	6 ½
8-FT. COUPLER:	15 ½	5	11	5	7

ALL DIMENSIONS ARE INSIDE MEASUREMENTS

FIG. 2. OPTIMUM DIMENSIONS OF AIR-COUPLERS TESTED WITH 12- AND 15-IN. SPEAKERS

The 8-ft. Air-Coupler:

Comments from our readers had given us a very good idea of what would happen when a 15-in. speaker is attached to a 6-ft. coupler: some terrific resonant peaks. (One reader reported that these came at 33 and 58 cycles.) So we decided to start in directly with the 8-ft. Air-coupler. We first used the Altec 600-B speaker, and located it in the same relationship to the port as on the smaller coupler. This means that the edge of the speaker hole in the back panel was 1½ ins. below the port opening. The inside dimensions of the coupler were 94½ ins. long by 15½ ins. wide by 5 ins. from front to back. The port was located 3¼ ins. below the top, and was 5 ins. wide. Material of construction was ¾-in. plywood. No braces were used, since we wanted resonances to be as pronounced as possible.

Immediately noticeable were 1) in-

(Continued on page 34)

[1] G. A. Briggs, Wharfedale Wireless Works, *Sound Reproduction*, p. 122.

THE FAS SYSTEM

(Continued from page 33)

creased ability to handle high volume levels without breakup of the sound, or frequency-doubling effects, 2) a woody or boxy flavor to the sound, and 3) a very low-frequency resonant point. The sound power output on very low frequencies (below 100 cycles) was improved slightly, but the increased blur on tones between 100 and 400 cycles was annoying.

We are not going into the results of each experiment but we shall report what appears to happen when fundamental changes are made.

For instance, if the standard port is closed, and a similar opening made at the other end of the front panel, the Air-coupler behaves much like an ordinary air column. Certain frequencies become very pronounced. There are dozens of unbalanced resonances and harmonics. The boxiness of the sound is increased tremendously. It could not be minimized materially even when a 100-cycle crossover point was used.

If we revert to the port in its correct position, at the speaker end of the Air-coupler, we can experiment with changing the size of the port, changing the speaker location in relation to the port, and varying the size of the small top piece above the port.

The 15-in. Speaker:

Experiments with these three variables led to certain principles or characteristics which we found apply to either 15- or 12-in. speakers in 8-ft. couplers.

First, if we start with the speaker exactly opposite the port, and move it down until it is at the opposite end of the air-coupler, we increase sound output at very low frequencies but we also produce a beer-barrel boom. (Not, however, one-note bass!) Maximum brilliance — and minimum low-frequency response — are produced when speaker and port are opposite one another.

Second, increasing either the thickness or width of the coupler does not result in any marked improvement. We found in our first series of experiments with 12-in. speakers that keeping the width of the Air-coupler within 2 to 3 ins. of the speaker size (i.e., 14½ ins. inside for a 12-in. unit) was optimum. Therefore, for the 15-in. speaker, we used an inside dimension of 15½ ins. wide. Similarly, the thickness of the coupler reached optimum at 4½ ins. inside for 12-in. speakers. For the 15-in. unit, we compared couplers whose inside dimensions were 5 and 9 ins. thick. The tests confirmed what we already knew: increasing the thickness extends bass response

(Continued on page 35)

THE FAS SYSTEM

(Continued from page 34)

slightly but, for equal levels of sound-power output, a greater driving power is required. If the coupler is made too thin, extreme lows begin to drop out.

Third, and this phenomenon is familiar to all who have worked with vented enclosures, the port opening on the coupler can be adjusted for optimum balance between speaker and air resonances. To give an example from an outside authority, Briggs reports that cone and air resonances for a 12-in. speaker dropped from 42 and 68 cycles, respectively, with a 9- by 9-in. port, to 33 and 66 cycles with a 9- by 2-in. port. The speaker for Briggs' tests had an open-baffle resonance at 65 cycles. To tune the port, cut the piece "D" (Fig. 2) larger than necessary; then slide it back and forth until optimum results are secured.

The fourth factor is the crossover point. With the Altec or GE 12-in. speaker on a 6-ft. Air-coupler, we found that 350 cycles gave best results. The use of a lower point on FAS installations is somewhat a matter of personal listening preference and, much more important, the characteristics of the rest of the system. If the middle-range speaker is highly efficient at low frequencies, the listener may want to reduce the crossover point to 250 cycles.

With 15-in. speakers on either 6- or 8-ft. Air-couplers, plus the Jensen HNP-51 for the middle and high range, we preferred a 200-cycle crossover point, particularly on the 8-ft. coupler. We tested a 100-cycle crossover, but found that the bass response in the 75- to 150-cycle range was weak. From 75 cycles down, the coupler came into action and produced undue emphasis on the extreme lows.

Conclusion:

With these four principles established for 15-in. speakers and 8-ft. couplers, optimum performance of the FAS system can be established under a wide variety of conditions. The specifications we found best for our particular set of conditions are given in Fig. 2. To simplify the drawing only the top half of the Air-coupler is shown. You may want to modify these to suit your own equipment. It should be emphasized again that no braces were used on the Air-couplers in these experiments. Resonances arising from the wood construction will be reduced if three or four braces are used on the back panel. Two or more, unequally spaced on the front panel, should be tried if needed.

The major advantage of an 8-ft. Air-coupler is its ability to handle greater volume levels. This advantage is particularly apparent when especially designed woofers, such as the Jensen PI5-NL, are used. Such woofers are to be preferred to wide range units, and are almost essential for 8-ft. units operated at high volume levels. The longer Air-coupler extends the low frequency range slightly, but except in special applications, this is hardly necessary since 30 cycles are well within the range of the standard 6-ft. coupler and 12-in. speaker.

The 8-ft. coupler with a 12-in. speaker provides approximately the same advantages over the standard size, namely, greater volume-handling ability. But, at normal levels for home listening, sound-power output is better with a 6-ft. coupler.

When a comparison is made between 12- and 15-in. speakers on 6-ft. couplers, we find that sound-power output is improved in the 50- to 100-cycle range at medium and high volume levels, but there is no appreciable difference in sound-power output at low levels. However, this conclusion should be made with care, since 12- and 15-in. speakers differ considerably in efficiency.

EDITOR'S NOTE: *This is the fourth in a series of articles on the FAS audio system. Previous installments, which ap-*

(Concluded on page 38)

DESIGN DATA for AF AMPLIFIERS — No. 8 Variable Equalizers

PART 1 — WHY VARIABLE EQUALIZERS ARE DESIRABLE — CHARACTERISTICS OF EQUALIZERS — CIRCUIT FOR A SIMPLE BUT EFFECTIVE VARIABLE EQUALIZER

THE term "variable equalizers" includes such a wide variety of circuits in its literal definition that some restrictions must be applied to its use in these Design Data Sheets. When used herein, the term signifies a combination of bass and treble controls which provide either boost or attenuation, continously variable, without affecting the levels of frequencies in other parts of the audio spectrum.

Practical variable equalizers provide control over approximately the upper and lower thirds of the spectrum. Fig. 1 shows response curves of a typical equalizer with various control settings. As can be seen, each control affects only one end of the audio range. The level of middle frequencies remains unaffected by control settings. Thus, according to the settings of the bass and treble controls, curve A, B, C, or any intermediate curve can be combined with curve E, F, G, or any intermediate curve. Such wide control of response is employed to provide proper

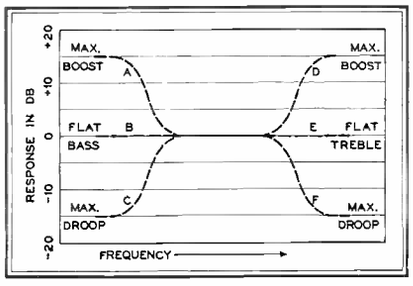


Fig. 1. Control range of ideal equalizer

equalization for any disc- or tape-recording characteristic, for individual listening preferences, and even for room acoustics and listening conditions.

Variable equalization can be accomplished by the use of resonant LCR circuits, which have lowest insertion loss; by non-resonant LR and CR combinations; or by simple CR circuits, which generally have greatest insertion loss. This Design Data Sheet describes a simple and highly satisfactory circuit which provides about 14 db boost or attentuation at 50 and 10,000 cycles, and which utilizes only C and R components. Because no coils are involved, no hum-pickup problems should be encountered, and the cost of components is relatively low. The circuit is given in Fig. 2.

The matter of equalizer circuit placement in the audio system should be considered carefully. The ideal place for a variable equalizer is, of course, in the preamplifier if an individual preamplifier with operating controls is used. It should then be preceded by at least one stage of amplification, preferably two, in order to minimize hum pickup at low signal levels. The equalizer input should be fed directly from the plate resistor of the preceding stage, and the output should be connected directly to the grid of the following stage. A volume control or coupling network must not be used at either the input or output of the equalizer circuit shown.

The circuit can be incorporated in the main amplifier if necessary. However, it cannot be included in a feedback loop under any circumstances. If it were so included, the boost or droop action would be diminished severely, if not nullified, by the feedback. Thus, it must be placed at or near the amplifier input, outside the feedback loop if one is used.

The tube used can be almost any triode normally employed in AF amplifiers. If a high-mu-triode such as a 6SQ7, 2A6, 6B6-G, or 6S8-GT is used, the insertion loss of the equalizer is can-

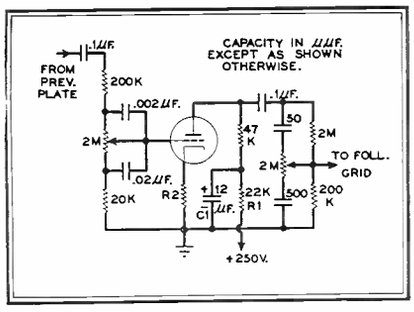


Fig. 2. Non-resonant equalizer gives good results

celled. This permits its addition to existing equipments without extensive alterations.

R1 and C1 make up a decoupling network, which should be included to reduce the tendency toward instability caused by the addition of an extra RC-coupled stage. If the B supply exceeds 250 volts considerably, the values of R1 and C1 can be increased. R2 should be chosen in accordance with RC-Coupled Amplifier Charts for the tube used, as explained in Design Data Sheet No. 4.

Should the total gain be found insufficient upon addition of the variable equalizer, a cathode bypass capacitor can be added for R2. Its use is not recommended unless absolutely necessary, however, since there can be no other feedback employed in this stage.

Design Data Sheet No. 9 will include data on a different type of non-resonant variable equalizer and a discussion of resonant equalizers.

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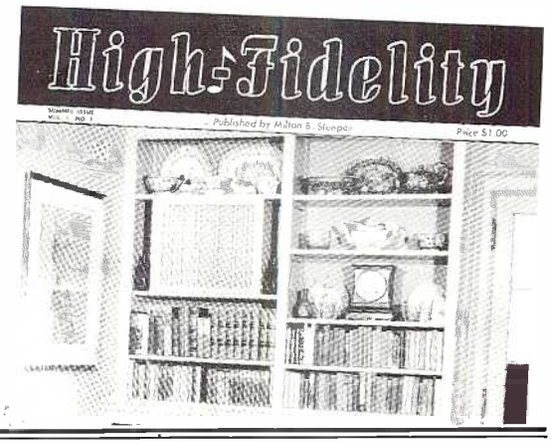

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THE FAS SYSTEM

(Continued from page 35)

peared in October, November, and December issues, covered the amplifier and speaker system developed for optimum results from this system, and told how to adapt the FAS system to existing equipment. In the March issue, we shall review reports from readers on the results they are achieving, and present a tentative design for a reflex or double air-coupler. Readers are invited to send the author complete details of their experiments.

ST. PAUL RADIO SYSTEM

(Continued from page 22)

merely pushing a button at headquarters may suggest the use of extremely complicated and costly equipment. Actually, that is not so. We have increased our capital investment in radio about 15%. The radio transmitters and receivers are standard Link models. The addition of selective calling units is a simple matter. No delicate mechanism is involved, for the only moving parts are standard telephone relays, of which millions are already used in telephone systems

Our list of radio-equipped vehicles is as follows:

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1 Ambulance
1 Spare ambulance (in reserve)
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14 Detectives' cruiser cars
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3 3-wheel motorcycles
9 Solo motorcycles
3 Emergency panel trucks

We also have three portable transmitter-receiver pack sets.

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Editor's Note: The second and concluding part of Commissioner Peterson's article will discuss the radio installation and selective calling system installed for the St. Paul fire department.

INDEX OF ADVERTISERS

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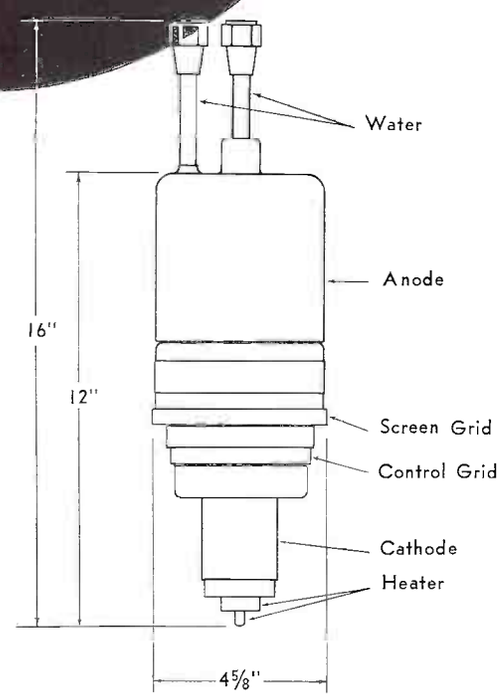
D-C Plate Current	7.1 Amps
D-C Screen Voltage	1000 Volts
D-C Screen Current	600 Ma.
DC- Grid Voltage	—310 Volts
Peak R-F Grid Input Voltage (approx.)	485 Volts
Plate Power Input	39 Kw.
Plate Dissipation	19 Kw.
Plate Power Output	20 Kw.



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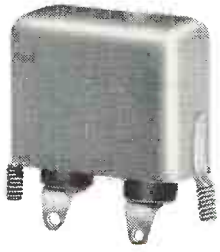

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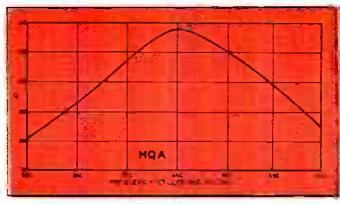

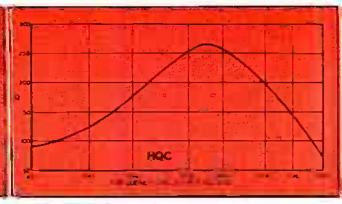

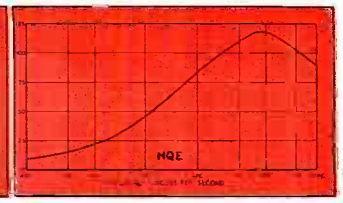

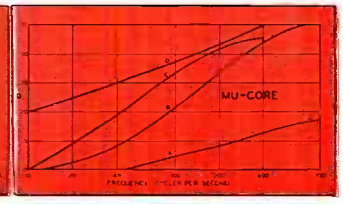

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HQA-13	2. hy.	11.00	HQB-10	12. hy.	22.00	HQE-3	50 mhy.	7.00
HQA-14	3. hy.	13.00	HQB-11	18. hy.	23.00	HQE-4	100 mhy.	7.50
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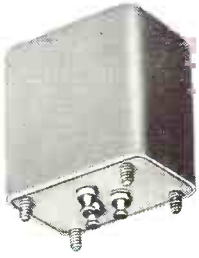
UTC INTERSTAGE AND LINE FILTERS



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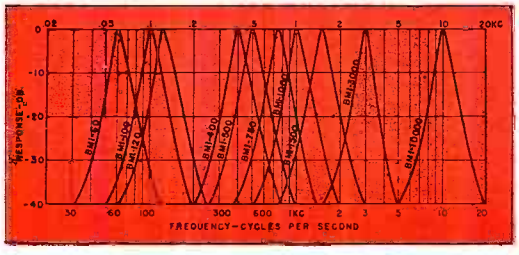

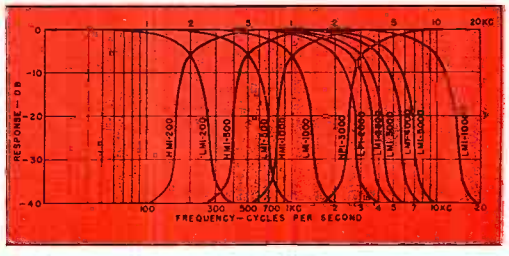

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BMI-500	HMI-500	LMI-3000	LML-1000
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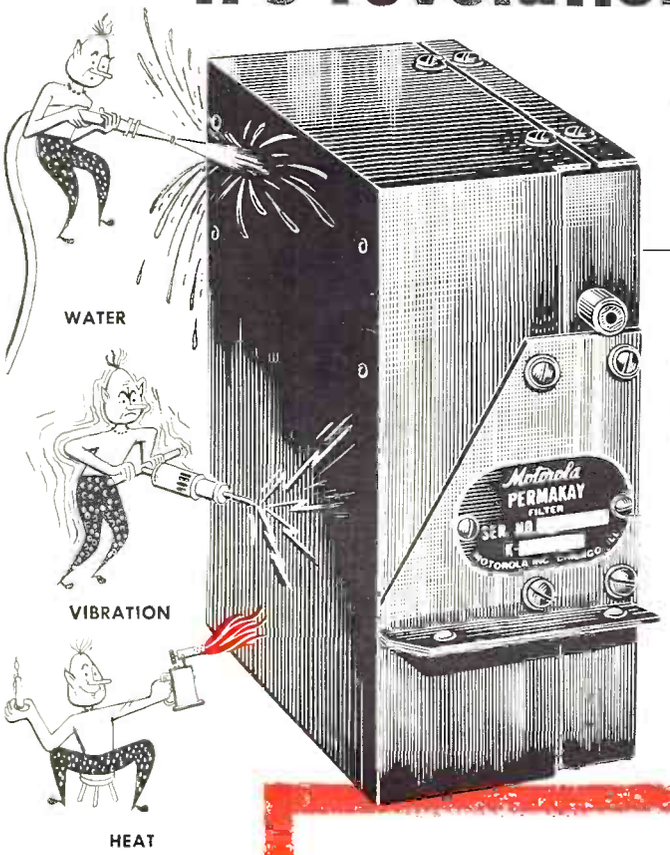

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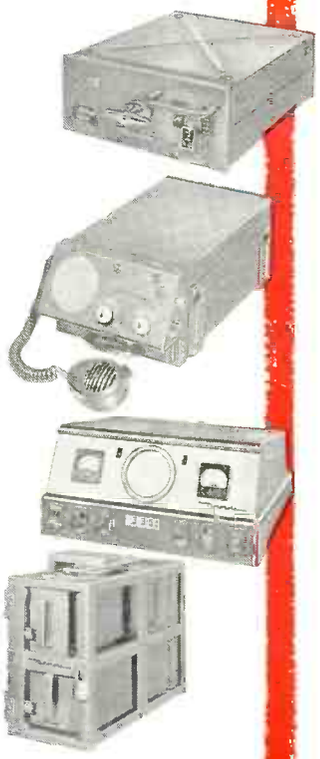
Motorola's amazing invention . . . THE SENSICON PERMAKAY FILTER FOR GUARANTEED PERMANENT SELECTIVITY! *Thousands in the field, operating year in and year out, without failure.*



Permakay is here to stay as the keystone of the Sensicon Circuit

The Permakay I.F. Wave Filter for PERMANENT SELECTIVITY—*guaranteed for the life of the set!* This coil and capacitor filter network is noise-balanced for optimum signal-to-noise ratio, achieved by counterphasing. These super-precision elements are cast in solid waterproof plastic which will not melt, crack, loosen, or deteriorate. PERMAKAY thus assures *permanent* precision selectivity, reduces maintenance, and increases all-around serviceability of your Motorola equipment.

. . . AND HERE AGAIN THE *MOTOROLA GUARANTEE* provides perfect radio service today and protects against obsolescence tomorrow. When radio channels are split you need not buy a new receiver — simply exchange the standard-channel Permakay filter for a new split-channel filter and your receiver is up to date and ready for years of service.

Motorola FIRSTS

TRUE ADJACENT CHANNEL

SPLIT CHANNEL

SENSICON CIRCUIT

PERMAKAY*

statomic oscillator

iso q cavities

differential squelch

capacitance discriminator

instantaneous deviation control

bridge balanced crystal oven

SO INSIST ON SENSICON and protect your investment!

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