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RELIABILITY OF TRANSISTORS

IN BROADCAST STUDIO USE

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Technical Products Operation

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RELIABILITY OF TRANSISTORS IN BROADCAST STUDIO USE

The transistor era in broadcast TV equipment is now about three years old. During the years we have seen increasing acceptance of transistors on the part of industry. Broadcasters now realize more fully that they can expect advantages from the purchase of transistorized equipment.

General Electric entered quite early into the field of transistorized equipment for broadcast and industrial use. As a result, considerable field experience has now been obtained for transistorized equipment. It is the purpose of this paper to review this field experience and to publish performance results on the BC-21-A Audio Console and the PG-4-B Sync Generator. The advantages that transistors can offer to broadcast equipment designs are identified and future trends analyzed.

Early in the history of transistor application we all looked at the solid state device with considerable question. As we originally attempted to obtain reliable and stable circuits many of us doubted that transistors would ever replace tubes, but experience has now indicated that transistors are here to stay. I am sure that users in the broadcast, industrial, and military fields are more than convinced that equipment of the future will feature increasing transistorization.

The advantages of transistorization for broadcast applications can be divided into five main categories. They are: reduced power consumption, reduced heat, better mechanical characteristics, improved stability, and improved reliability.

Little needs to be said about the first two categories. Reduction of power consumption as a direct item of operating expense is attractive in itself. The resulting reduction in required air conditioning for control rooms and the improvement in environmental conditions for all components in the equipment are, in some cases, even more attractive. Reduction of heat within the equipment has greatly increased the life of all components. Since it is very seldom that voltages on the major portion of the equipment exceed 50 volts, the general area of safety of personnel is also greatly improved.

Reduction of power consumption in many cases is quite dramatic. As an example, in equivalent tubed and transistorized vidicon chains we find a power reduction of 24 to 1, an IO chain indicates an improvement of 14 to 1, an audio console shows an improvement of 5 to 1, and we can go on making comparisons, but I am sure that you are willing to accept this obvious and outstanding advantage without further question.

In the mechanical area, the reduction in size of all components allows a great saving in volume and in weight. Since the mass of the individual components is greatly reduced, the equipment inherently has high resistance to shock and vibration. This might not appear to be of prime importance to the broadcasters, but it is this type of general improvement in equipment that contributes to better reliability. Probably one of the most important mechanical improvements is the elimination of microphonics. In transistorized cameras, microphonics from other than the pickup tube are nonexistent.

The improvement in operating stability of transistorized equipment is perhaps less readily recognized by those who have not experienced it. These improvements occur in part because of the properties of the transistors themselves and in part because of the improved circuit techniques that are often possible. Vacuum tubes are all subject to more or less drift of characteristics including relatively short time warm-up effects and long time aging effects. They are also quite sensitive to heater voltage changes. Changes in G_m and in DC operating points can be expected. Also associated with tubes are a host of other lesser effects. Microphonics, grid current, and cathode interface spiking are a few. In addition, random intermittent fluctuations often develop with age, due probably to damage caused by heat cycling, leading to many tube replacements, particularly in video equipment, when the basic properties of the tube still check o.k.

In contrast to tubes, transistors have no warm-up, no microphonics, and a minimum of aging effects. They do have characteristic changes with temperature but these can be very powerfully controlled by good circuit design. Stabilization of gain and DC operating point can be achieved to a higher degree than is possible with tubes because of the high inherent amplification factors in the devices themselves. Circuits using even moderate amounts of feedback exhibit excellent stability.

Most transistorized equipment designed so far has used germanium devices. Recently, inexpensive silicon transistors having a great variety of voltage and power ratings and outstanding high frequency performance have become available. Silicon transistors still cost more than germanium, but the margin is becoming less in terms of the overall equipment. The highly stable characteristic of the silicon transistor with temperature also allows the use of less elaborate circuit design to achieve these same results.

To date equipment on the market has continued to use tubes for high voltage and high power output circuits. Recent progress has been so rapid in all phases of transistor circuitry that it can be predicted now that new designs of many items will employ no vacuum tubes at all.

Today we can say that transistors can be used in all forms of circuit work for vidicon and IO cameras. Much effort in this area has been done for the military and the industrial market and will continue into the broadcast market.

It seems that when the word transistor is mentioned that the immediate question is: "Well, aren't they too noisy?" This apparently is a belief that was established early in the history of transistors and is still very common today. I am not saying that transistors are without noise, but I am saying that with good design many of the problems of noise can be worked around. As an example, it is possible to design an audio console with a noise level of -120 db. This, I think you will agree, is a pretty good audio console. On the other hand, the noise of a transistor is not consistently low enough today that it can be used as an input stage for a vidicon camera. We have yet to find a transistor circuit that can do better than a tube circuit in this particular application.

We have talked about all of the advantages of transistors but I am afraid everything is not on the positive side. There are definite disadvantages with transistors. The junction temperature of a transistor is very critical and once it is exceeded, the transistor is generally a candidate for the scrap box. A transistor hates over-voltage and is probably one of the best fuses ever invented.

I might add that from an engineering point of view, most transistorized equipment designed today has taken more time and more dollars than was originally set forth in any design schedule.

Even though transistor prices have dropped drastically during the last year, they still cost more than tubes. I am not sure that we can predict when they will be comparable to tubes in initial cost. Consequently much of the transistorized equipment has a higher initial cost than tube equipment. Since transistors react critically to extremes of both heat and cold, considerable effort must be expended during the design of equipment to provide good operation at these extremes. This has a very important beneficial secondary effect in that the design must be so conservative at normal operating conditions that there is inherently more reliability and more stability in the equipment than might otherwise be provided.

Records of operation of early designs in the field have begun to indicate a degree of reliability far greater than we might have anticipated. For example, data available on two types of broadcast equipment indicates that we have accumulated 1.5 million equipment hours of operation. In these two pieces of equipment there are 130 transistors, which gave us a total of 104 million transistor hours of operation. The average hours of operation of these units has been 10,800 hours which is an average of over one year operation per unit. The failure rate has been .9 transistors for this period of time. To put it in a better light, this means that there has been approximately one transistor fail per unit per year of continuous operation. Stated in yet another way, this is one transistor failure for every 900,000 hours of operation. Although these figures have been tabulated for only two types of broadcast equipment, we are receiving the same kinds of reports from other broadcast designs and from our transistorized industrial vidicon cameras.

One might ask how this compares with reliability statistics as prepared by the transistor manufacturer. This is a difficult question to answer because the transistor manufacturer lists his failures and failure rates as specific types of failure or malfunction of the device. Our records indicate only that transistors have been replaced and we do not have any record of causes. We have also generalized all types of transistors and most of the figures today are on specific types of transistors.

In publishing failure figures a transistor manufacturer would indicate malfunction of a unit if the normal beta of 40 dropped to 25. With good design techniques the beta could drop to 10 without malfunction of the circuit. Military records indicate that approximately half of the transistors replaced were actually good transistors. We would expect that this same type of thing is happening in the broadcast industry with transistors.

Transistors are continually improving and the transistor designers predict that life of transistors in the future should be many times what they are today. Therefore, we can expect an era when maintenance of equipment using transistors will be almost nonexistent.

We can now say with confidence that transistors will be used in ever increasing numbers in broadcast studio equipment. You, as broadcasters, will realize the benefits of this new device in improved performance, greater reliability, and reduced operating and maintenance costs.

FALCON AERONAUTICS, INC.

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WHAT THE FAA RULES AND PROCEDURES MEAN TO THE BROADCASTER

Congratulations! I commend the broadcast industry for its outstanding safety record. There has never been a mid-air collision between two antenna towers. Of this you may be justifiably proud.

I don't know how much of this may be attributable to the rules and regulations of the Federal Aviation Agency with respect to allocation of airspace; but it is a fact that these rules and regulations do exist - they affect you, the broadcaster. You may not like them, but you should understand them. An understanding of FAA's rules and regulations in airspace matters can save you time and money when it comes to building new transmitting towers, or increasing the height of existing towers.

The body of these rules and regulations is contained in Part 626 of the Regulations of the Administrator, which has as its basis the Federal Aviation Act of 1958. The highlights of Part 626, as it now applies, are:

1. It establishes the requirement for notice of proposed construction or alteration of transmitting towers and other structures.

2. It lays down criteria for the determination of hazards to air navigation.

3. It provides for aeronautical studies of the effect of certain proposed construction on the use of the navigable airspace.

4. It defines the procedure for appealing an adverse decision.

5. It authorizes the establishment of antenna farm areas.

Part 626 became effective on July 16, 1961, less than one year ago. The purpose was to consolidate and strengthen a rather loose set of procedures which had grown up in the past, much like 'topsy'. The objective was to provide for more efficient use of the airspace - but it should be clearly understood that these rules and regulations, promulgated by the Federal Aviation Agency, are designed to provide more efficient use of the airspace by aircraft.

I think it is safe to assume that these rules and regulations will be amended, as the FAA acquires experience in their application. For example, a review of cases handled thus far might readily suggest changes in the criteria for the determination of hazard.

Aviation interests tend to regard tall structures, particularly transmitting antennas, as hazards to air navigation. Certainly this is the manner in which such structures are treated in the regulations of the FAA. Broadcasters might be equally justified in considering aviation requirements as a hazard to the dissemination of program material.

Suffice to say that the interests of aviation and broadcasting collide head-on in areas of dense population, and particularly in those regions where cities tend to sprawl out across the countryside. Large metropolitan areas breed multiple airports, generate heavy airline and private flying, and weave an intricate network of air routes overhead.

On the other hand, these same densely-populated metropolitan areas, if they are to be adequately served by the broadcast industry, demand more and taller transmitting antennas, particularly in the fields of FM and TV.

Public interest is deeply involved in this controversy. It is interesting to note the results of recent aviation surveys, which reveal that less than 20 percent of our population has ever set foot in an aircraft; while the number of people who regularly utilize the services of broadcasters must surely exceed 99 percent.

Now I do not believe that we can expect the Federal Aviation Agency to be completely objective in applying hazard criteria to proposed antenna structures. After all, their business is air safety - a demanding and responsible task, in which the Agency has demonstrated great proficiency. The FAA has shown, in their conduct of informal airspace hearings, a sincere desire to consider the needs of broadcasters. The record reveals many instances wherein structures have been approved, despite the fact that the proposed dimensions exceeded the hazard criteria.

I have said that it is inevitable that the criteria for the determination of hazard, as specified by the Federal Aviation Agency, will be amended. Certainly the strict enforcement of this criteria, as contained in Part 626, would seriously curtail the necessary growth of broadcasting.

Similarly, the unrestricted construction of transmitting antennas, and other tall structures, would cripple the aviation industry, lay waste to airports representing investments of hundreds of millions of dollars, and hinder our national defense by reducing the effectiveness of a major system of transportation.

The problem calls for mature and statesmanlike understanding on the part of aviation and broadcasting alike. The Federal Aviation Agency, in assuming the role of arbiter of the efficient use of airspace, cannot ignore the need of the public to be served by the broadcast industry. Broadcasters, too, in proposing the construction of a new antenna, must be aware of its impact upon air navigation.

Unfortunately, the rules of air traffic control and air navigation are quite complex. It is safe to say that the application for construction of a transmitting tower in almost any metropolitan area will bring forth a list of from one to a dozen instances in which the proposed structure will violate FAA criteria. Under present procedures, the FAA does not attempt to classify these violations as to degree of significance, and the burden of determining the real impact of the structure upon aviation falls largely upon the applicant. Fortunately, the highways of the sky are not set in cement, and can be altered or elevated somewhat more readily than can a surface expressway. The broadcaster can take the initiative in recommending adjustments in aviation requirements, to accommodate the proposed structure. Similarly, aviation interests are quick to suggest alternative locations for proposed structures, lessening the impact upon established aviation routes. Such recommendations are generally debated in the informal airspace hearings conducted by FAA, and many of the cases have been resolved in favor of the broadcaster.

In attempting to minimize the effect of tall towers upon air navigation, the FAA has made provision in its regulations for antenna farm areas, to accommodate the grouping of several antenna structures in one location. The obvious purpose of an antenna farm area would be to localize the effect of tall towers upon the use of airspace by aircraft. There are indications that aviation interests would be willing to make extra concessions in terms of adjusting air routes, in order to concentrate such structures in one relatively small area. There are obvious advantages to the broadcaster as well. However, the Federal Communications Commission's standards on frequency separation are a vital consideration. Also, I am sure you engineers understand, far better than I, the vagaries of propagation in the various bands of the frequency spectrum. Thus far, no antenna farm has been formally designated by the Federal Aviation Agency, although some such areas appear to be in the making.

In summary, aviation interests want the capability to fly their aircraft with a minimum of obstruction from man-made structures. The Federal Aviation Agency, while charged with efficient use of airspace, is also charged with promoting air safety.

Broadcasters are interested in fertilizing what has been described as the 'vast wasteland', and wish to erect their transmitter towers to the optimum height and locate them in the position designed to give maximum coverage, to serve their ever-expanding market. The Federal Communications Commission, and the broadcaster, have a legitimate interest in this matter.

I don't believe anyone can say with certainty just what the FAA rules and regulations will mean ultimately to the broadcaster. It has been suggested that the Federal Aviation Agency cannot be completely objective in this matter. It remains to be seen what the result of impending formal appeals of adverse rulings will produce. Conceivably a final decision of 'hazard' by the Federal Aviation Agency could be matched against a decision of 'no hazard' by the Federal Communications Commission. Certainly we should not allow the situation to degenerate to a point wherein local governments, city and county, might seek jurisdiction over zoning of airspace and allocation of air routes - that could be chaotic.

I believe the public interest - of the 20 percent who fly, and the 100 percent who watch and listen - can best be served through federal regulation on a national basis.

A sincere attempt at mutual understanding of the problems and needs of both parties, and a continued spirit of cooperation by aviators and broadcasters alike, will go a long way toward resolving these problems in the public interest.

AN ALL TRANSISTOR UHF/VHF FIELD STRENGTH METER

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ALL TRANSISTOR UHF/VHF FIELD STRENGTH METER

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Cecil S. Bidlack Carl E. Smith

SUMMARY

In the past, field strength meters for television signal measurements have been portable. However their size and weight makes a two-man team a necessity to move them. In addition their power consumption requires either a 6 volt storage battery or 110 volt AC for their operation. Separate units are also required for UHF and VHF measurements. This paper describes the salient features of a truly portable field strength meter, designed for the use of the Federal Communications Commission in the New York City UHF-TV project. Both UHF and VHF television bands are covered in one instrument, measuring 9 x 12 x 9 inches and weighing only 17 pounds.

INTRODUCTION

The Federal Communications Commission is now conducting a test of ultra high frequency television transmission in the New York City area. A one megawatt ERP station is in operation on Channel 31 on the Empire State Building, which is also the site of existing VHF-TV stations. Measurements of the video signals are being made throughout the service area; inside buildings, on roof tops, at street level, and other locations where TV reception may be desired. Commercially available field strength meters, while portable, were not sufficiently portable to make the measurements required. Smith Electronics, Inc. was awarded a contract to develop and build 12 field strength meters to make the New York measurements.

The Smith Electronics, Inc. Model SM-1 Field Strength Meter shown in Fig. 1 is the first light weight all transistor field strength set with continuous tuning of all VHF and UHF channels, with the following features:

1) It is light, weighing only 17 pounds with cables, baluns and matching network.
2) It has low power consumption, 30 to 50 milliamperes at 12 volts, depending upon the setting of the audio volume control.
3) It is small in size, the aluminum case is 9 x 12 x 9 inches.
4) The gain of the set is stable with temperature compensation holding the variation in gain to less than ±2 db over a temperature range of 25° to 75° F.
5) The SM-1 is highly reliable. Five sets were delivered to the FCC in August. Modifications were made in these sets at the time of delivery of seven additional sets in late September. Since that time one of the original group of 12 sets has been returned for repair. The trouble was found to be a poorly soldered connection.
6) It has a self-contained 12 volt nickel-cadmium rechargeable battery capable of operating the set continuously for eight hours. A power cord is provided which when plugged into 110 volt AC will fully charge the battery overnight.
7) Continuous tuning is provided over both VHF and UHF bands. A Mallory Inductuner is used at VHF and a Sickles tuned line front end is employed as the UHF tuner.
8) Monitoring is provided without the use of headphones by a 2" self-contained permanent magnet speaker. An audio amplifier supplies adequate power for comfortable volume.
9) A six step attenuator with a range of 100 db is split with half of the attenuation at radio frequency and half at the intermediate frequency of 41 mc. This attenuator is good over the range from 0 to 1000 megacycles.

Figure 2 is a block diagram of the meter. The signal from the antenna goes through the RF portion of the attenuator to the tuner which may be selected by means of a coaxial switch. Through an auxiliary switch, the battery supply is turned "on" to the tuner in service. Output of the tuner is an IF signal which passes through the IF section of the attenuator and to the input of the IF amplifier. A calibration control is provided for each tuner which is switched with the tuner. This calibration control varies the gain of the 2nd IF amplifier stage. The audio portion of the IF signal goes straight through all four IF stages to the discriminator, then through the audio amplifier to the loudspeaker. The meter signal is picked off the collector of the 4th IF amplifier stage, is detected, and passes through two DC amplifier stages, then through the four-position switch to the (200 μa) indicating meter. The four positions serve the following purposes:

1. Battery off
2. Peak measurement
3. Rms measurement
4. Battery condition of charge

PERFORMANCE SPECIFICATIONS

The SM-1 Field Strength Meter meets the following specifications:

Two continuous tuning frequency ranges:	54 to 220 mc and 450 to 900 mc
Input sensitivity:	50 μ volts or better (actually achieves 10 μ volts or better on VHF and 25 μv or better on UHF)
Attenuator range:	0 - 100 db in 20 db steps plus a 20 db meter scale making a total range of 120 db
Output reading:	Two meter scales: 0 to 20 db corresponding to 1 to 10 in voltage range
Gain stability:	Within ± 2 db from 25° to 75° F and within ± 1 db for 2 hours at room temperature

DESIGN CONSIDERATIONS

The SM-1 Field Strength Meter is comprised of six basic signal carrying units built into a compact aluminum carrying case. These units together with their controls, gear trains, power supply, and read-out devices are mounted on a heavy aluminum alloy structural panel, shown in Fig. 3, in such manner that the instrument is complete and operable independent of the cabinet or the front finishing panel.

The basic units are: the UHF tuner, VHF tuner, attenuator, IF amplifier, metering circuits, demodulation, audio and power supply. See Figs. 4 and 5. Interconnection between the RF and IF units is carried out by means of double shielded, 50 ohm coaxial cables and BNC connectors. The use of double shielded cables, together with individual shielding of each RF unit provides the isolation that is necessary to the stable operation of an instrument of this sensitivity.

UHF Tuner

Frequency selection is accomplished in the UHF tuner, shown in Fig. 6, by means of variable capacitors arranged to resonate inductors which are in the approximate form of a transmission line. No RF amplifier is used in the UHF range. Coupling from the first resonant circuit to the second is obtained by way of an opening cut into the shield between the two adjacent RF transmission line resonators. The size of the opening is adjusted to give approximately critical coupling between these circuits, and therefore maximum RF transmission and selectivity.

A UHF diode is used as the UHF mixer. A copper wire link passing through the second RF transmission line resonator and also through the local oscillator resonator provides the oscillator and signal combination which is applied to the UHF diode for conversion to the 41 mc intermediate frequency. The IF signal is then applied to a transistor which feeds a transformer tuned to 41 mc. The secondary of this transformer is adjusted to provide a generator impedance of 50 ohms similar to that of the VHF tuner. VHF-UHF switching, as well as attenuator switching, can therefore be carried out between 50 ohm generators and terminations by means of a low standing wave ratio RF switch without introducing irregularities due to varying terminations at different switch positions.

The UHF local oscillator is a grounded base MADT transistor oscillator similar to the VHF oscillator. The frequency determining circuit is a RF transmission line resonator tuned by a variable capacitor. The oscillator frequency is tracked to operate at a frequency 41 mc lower than the selected signal frequency over the signal range of 450 mc to 900 mc.

VHF Tuner

Variable inductors are used for frequency selection in the VHF range. The variation is obtained by means of a sliding contactor on a multi-turn spiral of silver ribbon. See Fig. 7. Tracking of the three identical coils is obtained by means of adjustable fixed tuned trimmer capacitors and inductors.

The converter system is composed of one RF stage, a transistor-mixer, and a local oscillator shown in Fig. 8. Oscillator power is applied to the base of the mixer transistor and the signal is applied to the emitter. Two tuned RF circuits are used for selection of the desired frequency. These are connected as low pass filters for maximum rejection of all frequencies higher than the desired signal. Series circuits tuned to short circuit the 41 mc IF signal provide the necessary rejection of signals on or near the IF frequency. These circuits reduce the spurious response of the instrument to a satisfactory level.

The mixer transistor feeds a transformer tuned to 41 mc. The secondary of this transformer is adjusted to provide a generator impedance of 50 ohms in order to present a constant generator impedance to the IF amplifier independent of the setting of the 50 ohm IF attenuator.

The VHF local oscillator is a grounded base MADT transistor oscillator. The frequency determining circuit in the collector circuit of the transistor is tracked to operate at a frequency 41 mc higher than the selected signal frequency over the signal range of 50 to 220 mc.

Attenuator

The attenuator is a tandem unit consisting of two turret attenuators each furnishing 0 to 50 db attenuation in 10 db steps and ganged to a common shaft as shown in Fig. 9. The attenuator pads consist of resistive elements in π sections contained in a precision machined rotor assembly. As the concentric shafts are rotated, the separate attenuator pads connect to the input and output BNC connectors.

Each section of the attenuator is designed to operate from 0 to 1000 mc with low VSWR, insertion loss, and high accuracy. In the SM-1, one section is used as an RF attenuator and the other section as an IF attenuator, thus providing a total of 20 db attenuation per step.

IF Amplifier

Four tuned stages of IF amplification, as seen in Fig. 10, are used to amplify the signal to the metering level of about 5 volts peak. The first stage of IF amplification is contained in each of the converting units.

The IF amplifier unit contains four tuned stages of amplification operating at 41 mc and a limiter and FM discriminator. The fourth stage feeds the meter circuit detector amplifier for field strength read-out and the FM demodulation circuit limiter and discriminator for audio monitoring.

Each stage of IF amplification is partially self-compensating for temperature variation by means of large resistors in the emitter circuit of each transistor. These resistors tend to maintain constant emitter-collector current and therefore constant gain over a wide temperature range. Since the self-compensation is not sufficient, a further compensation is obtained by using selected thermistors, as needed, with negative temperature coefficients for the emitter resistors. By this means, the overall gain of the field strength meter is maintained within ± 2 db at any one frequency over a temperature range of 25° to 75° F.

Metering Circuit

A video detector fed by the fourth IF stage is connected to a current amplifier consisting of two cascaded emitter followers. See Fig. 9. High current gain is necessary to provide a sufficiently fast charging time for the high capacitance peak voltage holding capacitor. The capacitor must be large in order to hold voltage between pulses within a small percentage of the peak voltage of the vertical sync pulses. As a peak reading meter the instrument reads within 1 db at the peak voltage of the vertical TV sync pulse.

Demodulation and Audio

A discriminator operating at 41 mc is used for demodulation of the FM audio signal. Audio from the discriminator feeds an audio amplifier designed to produce high audio level of fair quality at a minimum drain of battery power. See Fig. 9.

Power Supply

A 12 volt rechargeable nickel-cadmium battery provides power for operation of the field strength meter shown in Fig. 4. The battery has sufficient capacity for continuous operation of the meter for an eight hour day. Although the battery itself has a relatively constant discharge voltage, all circuits except the audio amplifier and UHF oscillator are regulated. About a 40 to 1 improvement in regulation is achieved by a Zener diode controlling an emitter follower. The regulator holds the battery voltage to within 0.05 volt.

NEW YORK UHF-TV TEST APPLICATION

Fourteen of these meters are now in service by FCC making measurements of signal strength in the New York UHF-TV Test. The Columbia Broadcasting System and A.D. Ring and Associates, representing Maximum Service Broadcasters, have purchased sets for making measurements in the New York area.

ACKNOWLEDGEMENT

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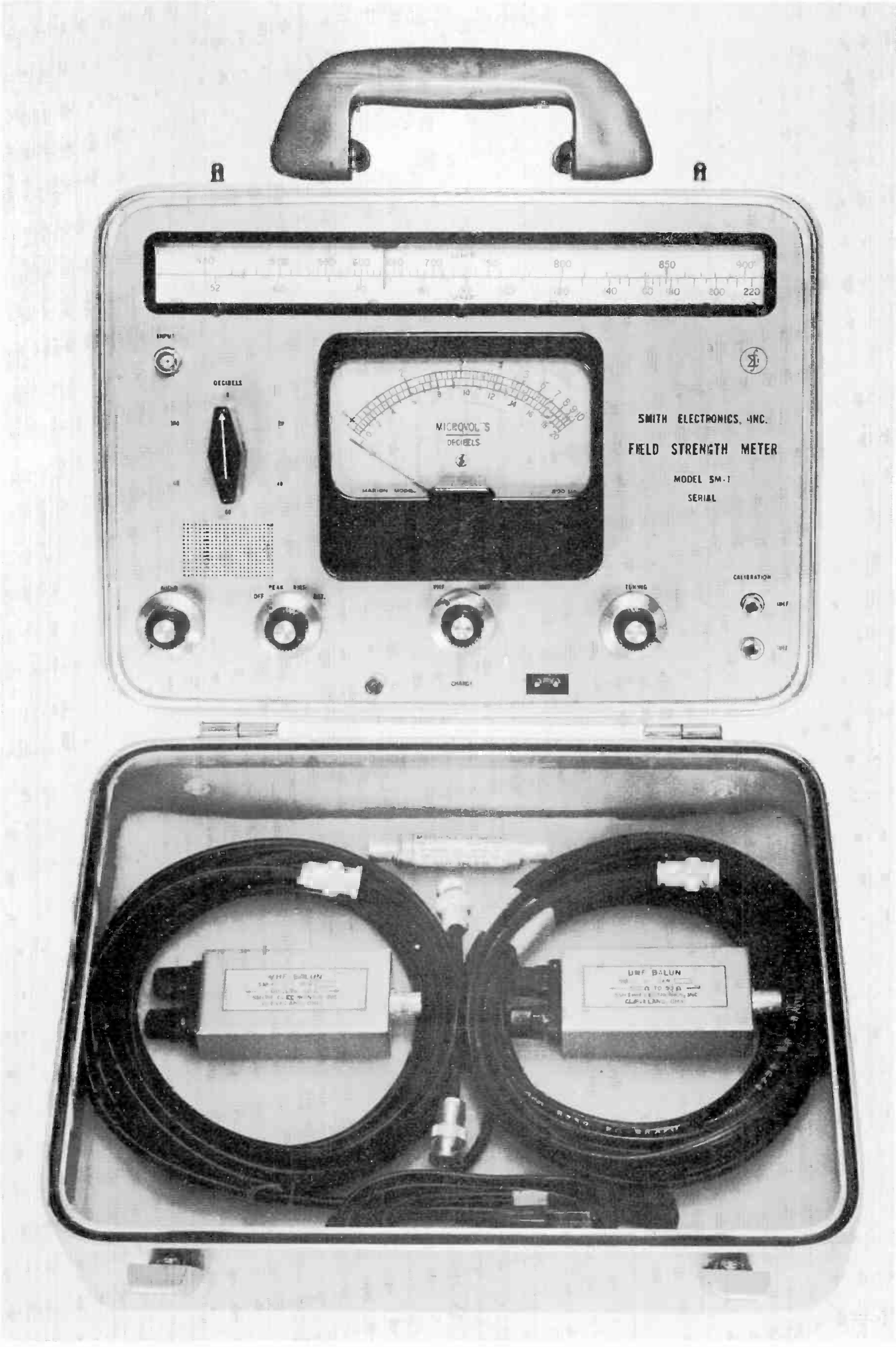
CONCLUSIONS

While the Smith Electronics SM-1 meter was built to cover only the television bands and the FCC requirement was for a meter without antennas or calibration, we believe that a completely portable instrument such as has been developed has untold possibilities for the future. A tunnel diode calibrator is available supplying a 1 millivolt signal at selected spot frequencies and an antenna kit is under development.



MODEL SM-I FIELD STRENGTH METER

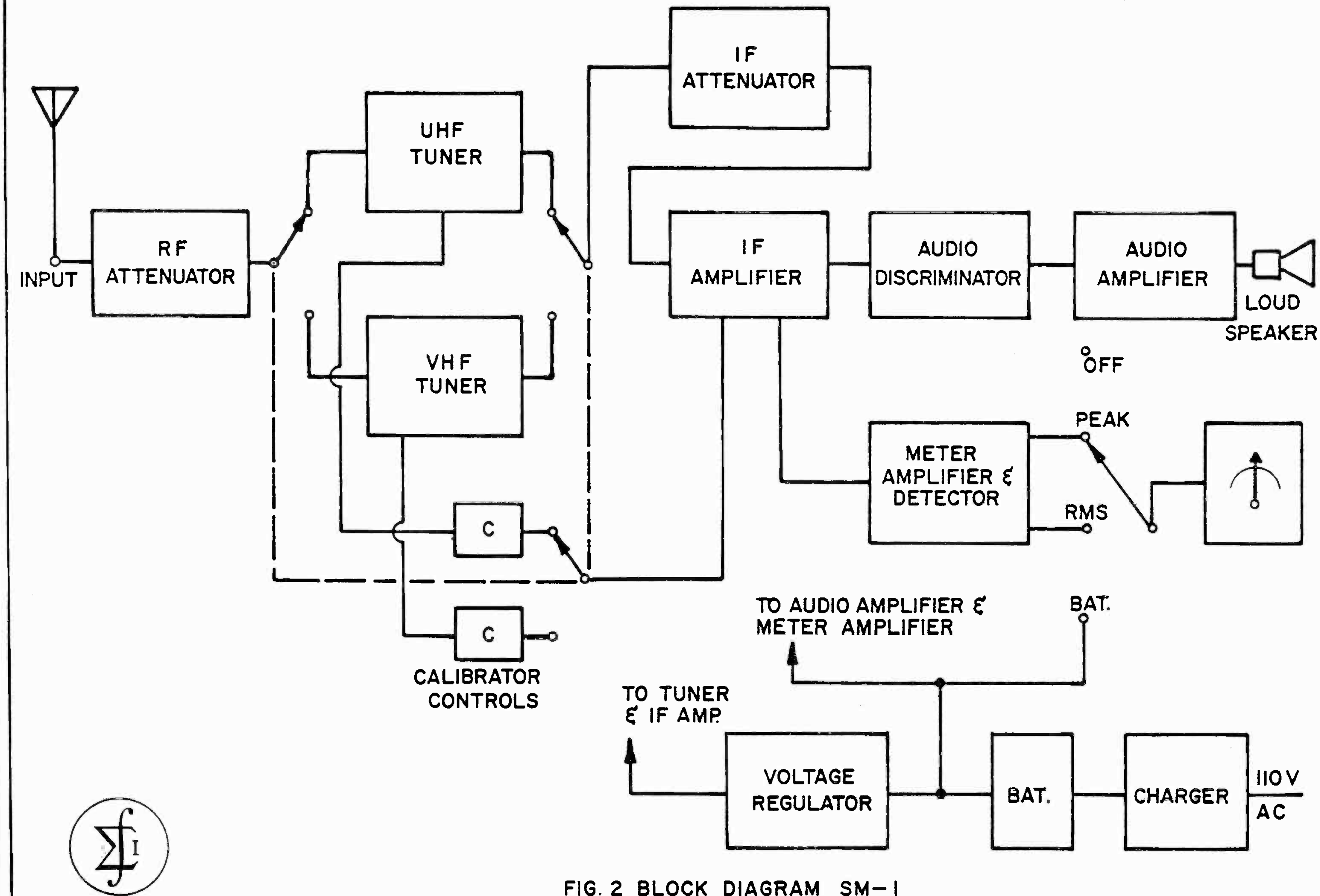


FIG. 2 BLOCK DIAGRAM SM-1

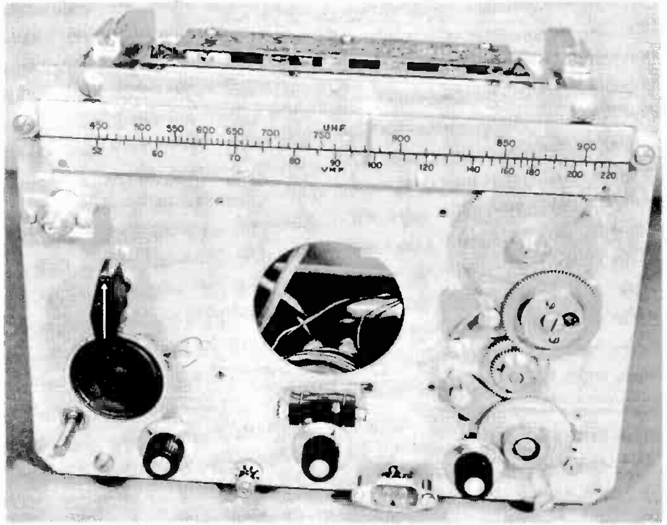


FIG. 3
STRUCTURAL PANEL

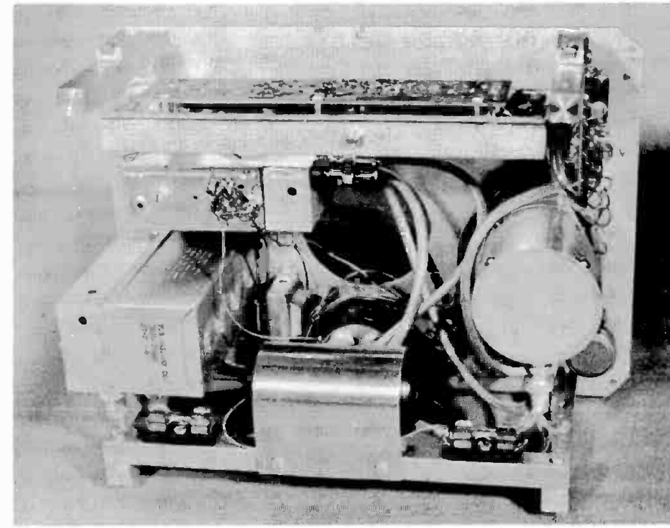


FIG. 4
REAR VIEW OF CHASIS

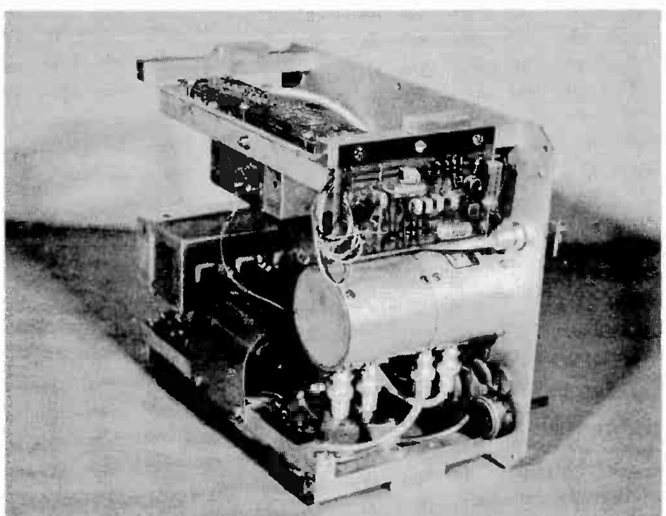


FIG. 5
END VIEW OF CHASIS

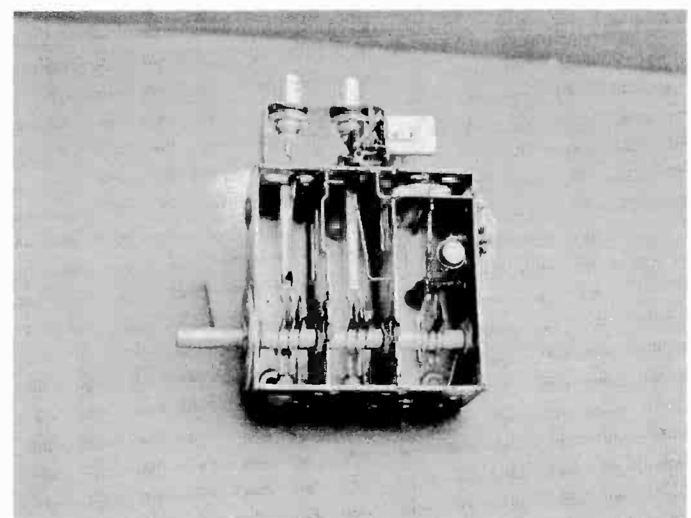


FIG. 6
UHF TUNER

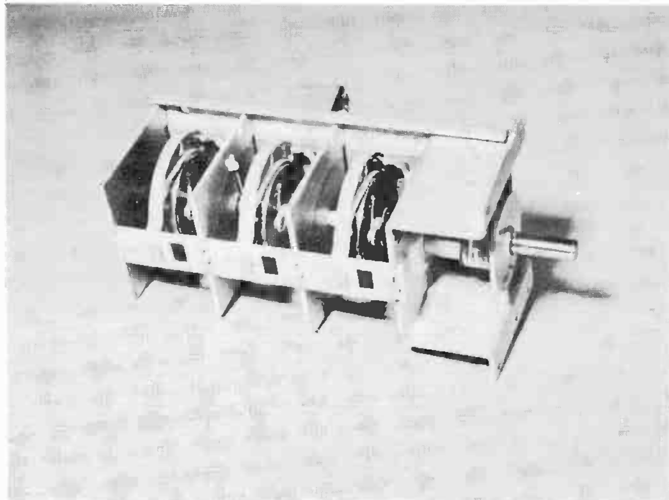


FIG. 7
VHF TUNER
VARIABLE INDUCTANCES

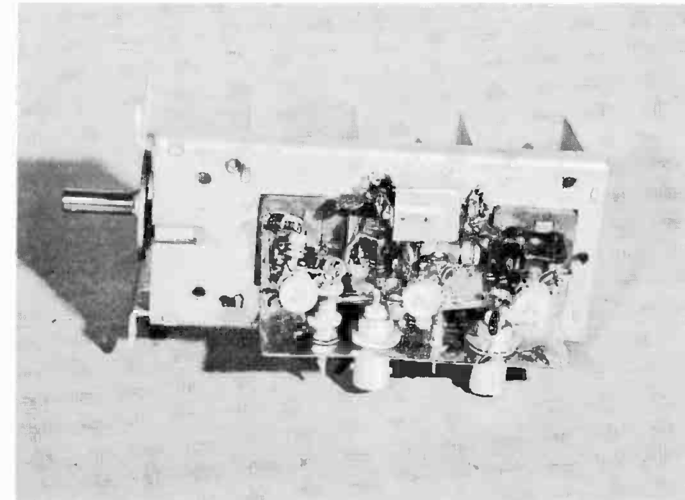


FIG. 8
VHF TUNER COMPONENTS

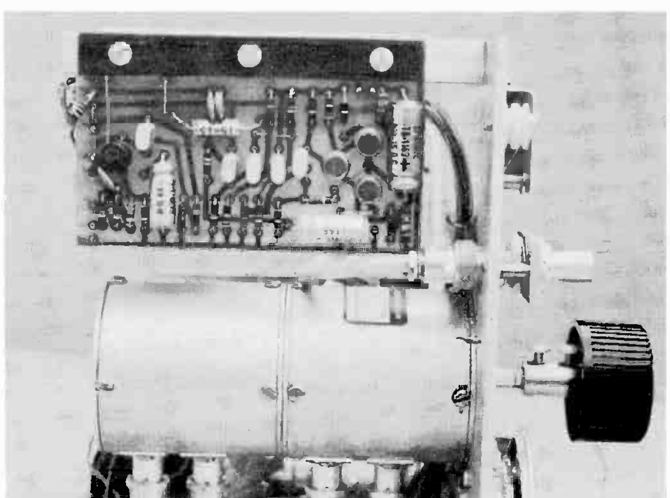


FIG. 9
ATTENUATOR AND AUDIO-
POWER SUPPLY BOARD

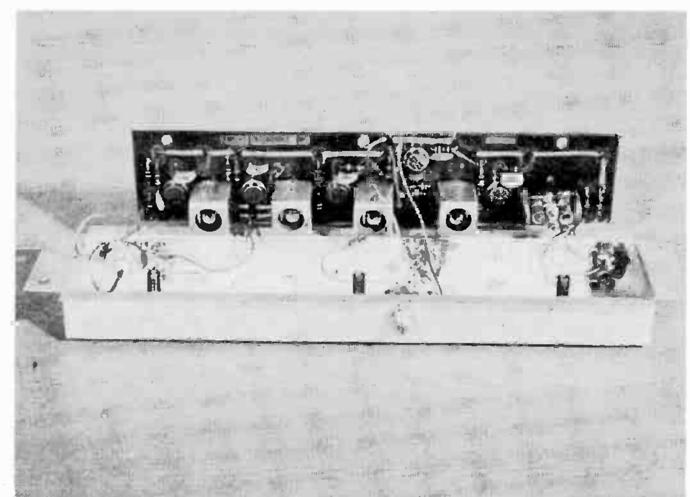
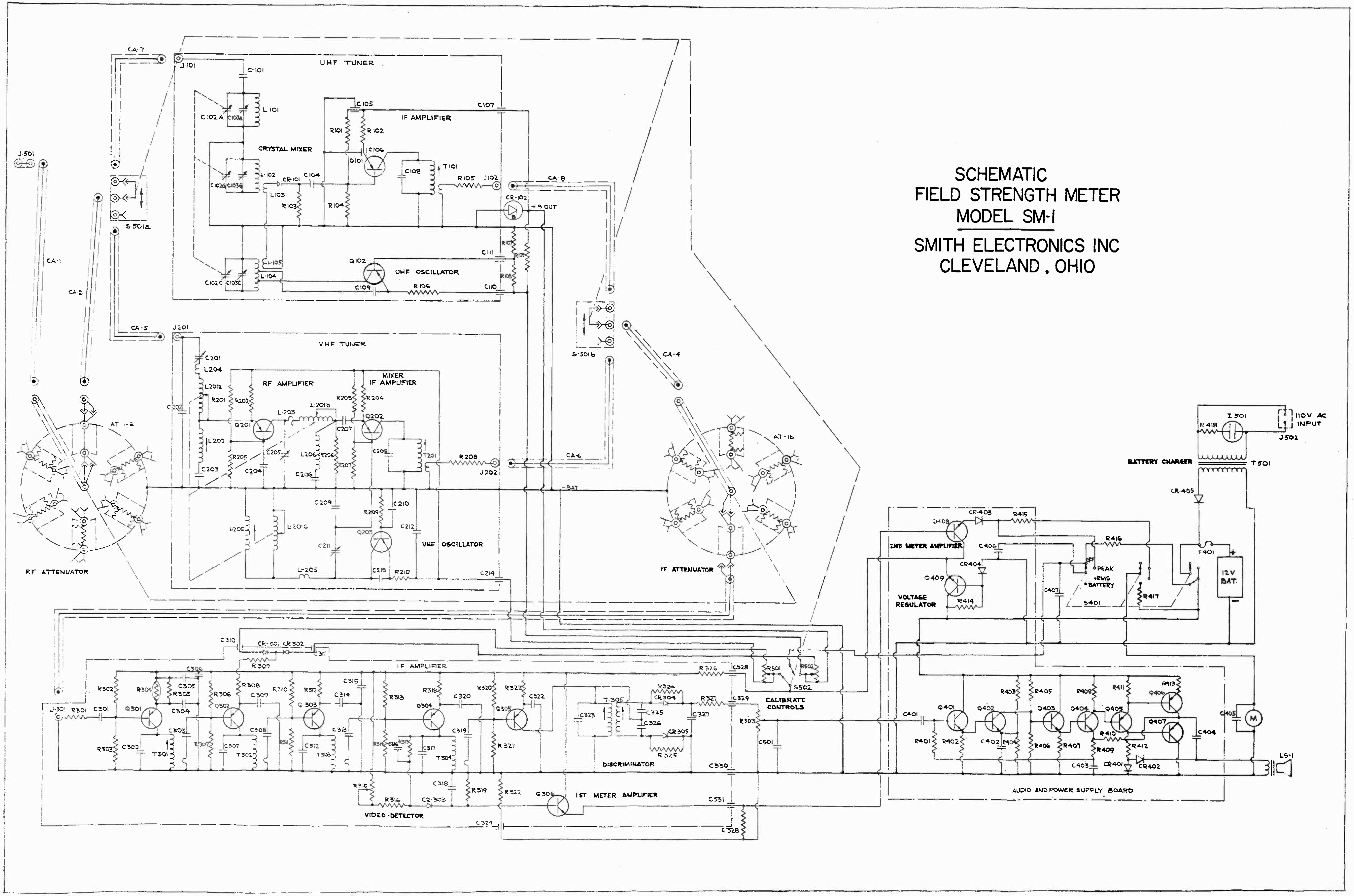


FIG. 10
IF AMPLIFIER COMPONENTS


SCHEMATIC
FIELD STRENGTH METER
MODEL SM-I
SMITH ELECTRONICS INC
CLEVELAND, OHIO
UHF TUNER
CRYSTAL MIXER
IF AMPLIFIER
UHF OSCILLATOR
VHF TUNER
RF AMPLIFIER
MIXER
IF AMPLIFIER
VHF OSCILLATOR
RF ATTENUATOR
IF ATTENUATOR
AT 1-a
AT-1b
S 501a
S-501b
BATTERY CHARGER
110V AC INPUT
12V BAT
2ND METER AMPLIFIER
VOLTAGE REGULATOR
PEAK
RMS
BATTERY
IF AMPLIFIER
DISCRIMINATOR
CALIBRATE CONTROLS
VIDEO-DETECTOR
1ST METER AMPLIFIER
AUDIO AND POWER SUPPLY BOARD

RECOMMENDATION FOR RAPID TRANSMITTER FAULT ISOLATION

Prepared by

Richard L. Uhrik

and

Everett J. Gilbert

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Cedar Rapids, Iowa

FOREWARD

The writers wish to express their appreciation for the suggestions and assistance given in the preparation of this document to Mr. Walter Jennings of Radio Station KRLD, Dallas, Texas.

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RECOMMENDATION FOR RAPID TRANSMITTER FAULT ISOLATION

INTRODUCTION

In recent visits to several radio stations, my attention was focused on the repair and maintenance problem. Three reasons for this problem becoming more serious are:

(1) Industrial demands are absorbing nearly all qualified engineers and technicians

(2) The trend toward complete remote operation is making the station more complex and removing potential on-the-job training

(3) The select group of dedicated broadcast engineers with over 20 to 25 years of trouble shooting know-how is fading away.

There is no need to take a pessimistic view of industry absorbing electronics personnel. Rather, consider industry as your source of engineers and technicians.

Some of the stations that have converted to remote control operation have reported reduction in down time. These reports may create over-confidence in the maintenance situation. Two observations to note in regard to remote stations are:

(1) Most remote stations are still being maintained by personnel who grew up with the equipment and are familiar with it;

(2) An entirely new situation may develop when personnel who did not grow up with the equipment are phased into remote-station maintenance.

I. INITIAL CONCEPTS.

The concept of rapid fault isolation is based on not wasting time in useless checking of areas where the fault does not exist. Since there is a terrific psychological pressure on the engineer or technician "racing-the-clock" trying to get equipment back on-the-air, he is liable (and also logically allowed) to make several quick, blind, "stabs-in-the-dark" to get the equipment back on the air or find these faults. These actions are based on past experience and intuition. This type of action is sound, and is further described in paragraph III, Immediate Action. However, there is a very definite limit to these hit-or-miss attempts to restore the equipment into an operating condition. The decision of when to stop the Immediate Action Approach and embark on the Fault Isolation Approach is for the chief engineer to make.

It is recommended that the Fault Isolation Approach be prepared in advance without the disadvantage of the mental strain of an equipment outage menacing every decision.

II. THE MAGNITUDE OF THE PROBELM.

A broadcast transmitter has 500 to 1500 electrical parts to which a schematic symbol number is assigned. It also has cables of 500 to 1000 wires, many mechanical parts, and miscellaneous items that can bring the sources of potential failure up to at least 5000 to 10,000 individual possibilities.

If it were possible to cut the unknown fault area in half by progressive steps, then it is theoretically possible to find the fault in fifteen steps:

$2^1=2$ $2^2=4$ $2^3=8$ $2^4=16$ $2^5=32$ $2^6=64$ $2^7=128$ $2^8=256$ $2^9=512$

$2^{10}=1024$ $2^{11}=2048$ $2^{12}=4096$ $2^{13}=8192$ $2^{14}=16384$ $2^{15}=32,768$.

Admittedly this is highly idealized, but it very clearly establishes the advantage of using a procedure that isolates a fault in a systematic procedure rather than a hunt-and-peck method of finding the fault.

Figure 1 illustrates peripheral effect on a transmitter and points out the need for definition of a fault. The most obvious indications of a fault anywhere in the transmitting system are:

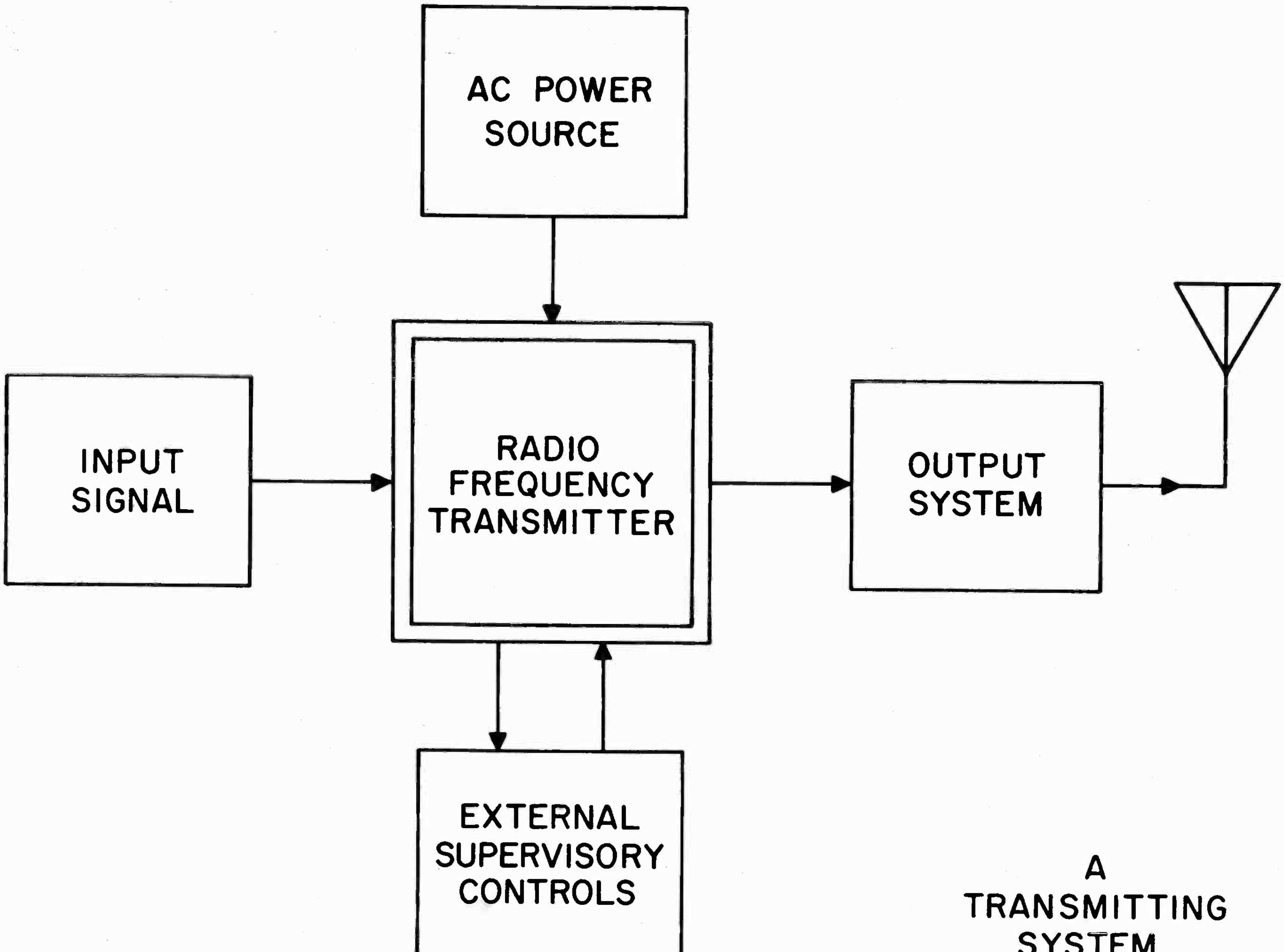
(1) No r-f output

(2) Degraded output, i.e., unintelligent or out of specification

(3) Intermittent output

Assume that any other problem that is likely to occur is not classified as a fault but rather treated as a routine maintenance problem.

Block diagrams similar to figure 1 should be a part of the Fault Isolation Procedure. They can and must be kept as simple as possible. If these block diagrams become to complex, they will not produce the effect of isolating the fault and suggesting a few key points to be checked. A series of block diagrams are recommended in order of electrical significance rather than a single complex diagram.



A
TRANSMITTING
SYSTEM

Figure 1
Page 3

Figure 1 also implies that several areas must be eliminated before the fault can be isolated to the transmitter. For example, the absence of r-f output will not indicate a potential transmitter fault until the following systematic procedure is established:

(1) Power source available

(2) Proper input signals available

(3) Proper setting of controls.

Note that a no r-f output fault under these circumstances is still conditioned by an output system fault.

III. IMMEDIATE ACTION.

There are two types of immediate action techniques. The first type is characterized by hopefully getting the equipment back in operation without specifically determining the cause of the fault. Here is where past equipment experience is extremely valuable in determining at least part of a formal procedure. Cycling the HV plate control on and off several times would be part of the procedure. If this does not help it would be advisable to shut the equipment completely off and then restart both filaments and plate circuits. The general opinion is that the mechanical vibration and wiping of contacts caused by this action may clear up the problem. Note that at this point we have assumed that the proper signal input exists.

The second type of immediate action is characterized by intuitive or other desperate measures to get the transmitter to operate. For example, if there is some indication of input power, a quick check of door interlocks would be in order. It is here where some of the more mundane techniques are in order; judicious tapping of doors, tubes, etc. Again, it is extremely valuable to record the exact recommendations of your own engineers and technicians at this point. There is no substitute for their years of actual operating experience in general, or particularly in regard to a specific transmitter.

The operator should not be burdened with a rigid list of immediate actions but allow to inject his own individual ideas. But the chief engineer must very carefully define when to stop the IMMEDIATE ACTION procedure and start the systematic FAULT ISOLATION procedure.

IV. FAULT ISOLATION.

It must be emphasized that this procedure is only a generalized approach and the operator must make decisions. Fifteen dicisions can find any one of 32,768 faults. This is not just 15 decisions, but 32,786 sets of 15 decisions. The formalized fault isolation procedure is primarily concerned with defining approximately the first one-third of all these possible dicisions. Proper formulation of the first group of questions will bring the operator into the near location of the fault. The subdivision of faults beyond this point depends on actual test equipment, the engineer's or technician's experience, age of the transmitting equipment, and many other factors. Perhaps the biggest factor for not extending a formalized procedure beyond this point is the time available to do the job, and bulk of paper necessary to tabulate the myriads of possibilities.

Figure 2 suggests the initial items to be checked. Actual terminal numbers and expected voltages should be specified at critical points on the FAULT ISOLATION block diagram. If there is any doubt about the terminal location, a properly marked Polaroid snapshot can be added to the block diagram.

The order in which the checks should be made and the degree of checking is generally a function of what precedes the fault. If the transmitter would not put out carrier when the initial turn-on procedure is followed, then the a-c power source and supervisory controls would be checked first. However, if the transmitter was in operation prior to the fault, a quick check of transmitter plate current would be in order, followed by a check for input signal. Usually it will take more than one check to give a particular area a tentative o.k. And it is often expedient to check several of the major areas to a limited degree before coming to any firm conclusion about whether a fault is located in a given area.

Again the overall concept of the formalized fault-isolation is emerging. The operator is confronted with a procedure for checking large blocks of circuitry wherein a fault may exist. However, due to the variation preceding a fault, the operator must decide the proper order in which to check out these areas. After several large areas are tentatively removed, the remaining large block or blocks of circuitry are then subdivided for further checking.

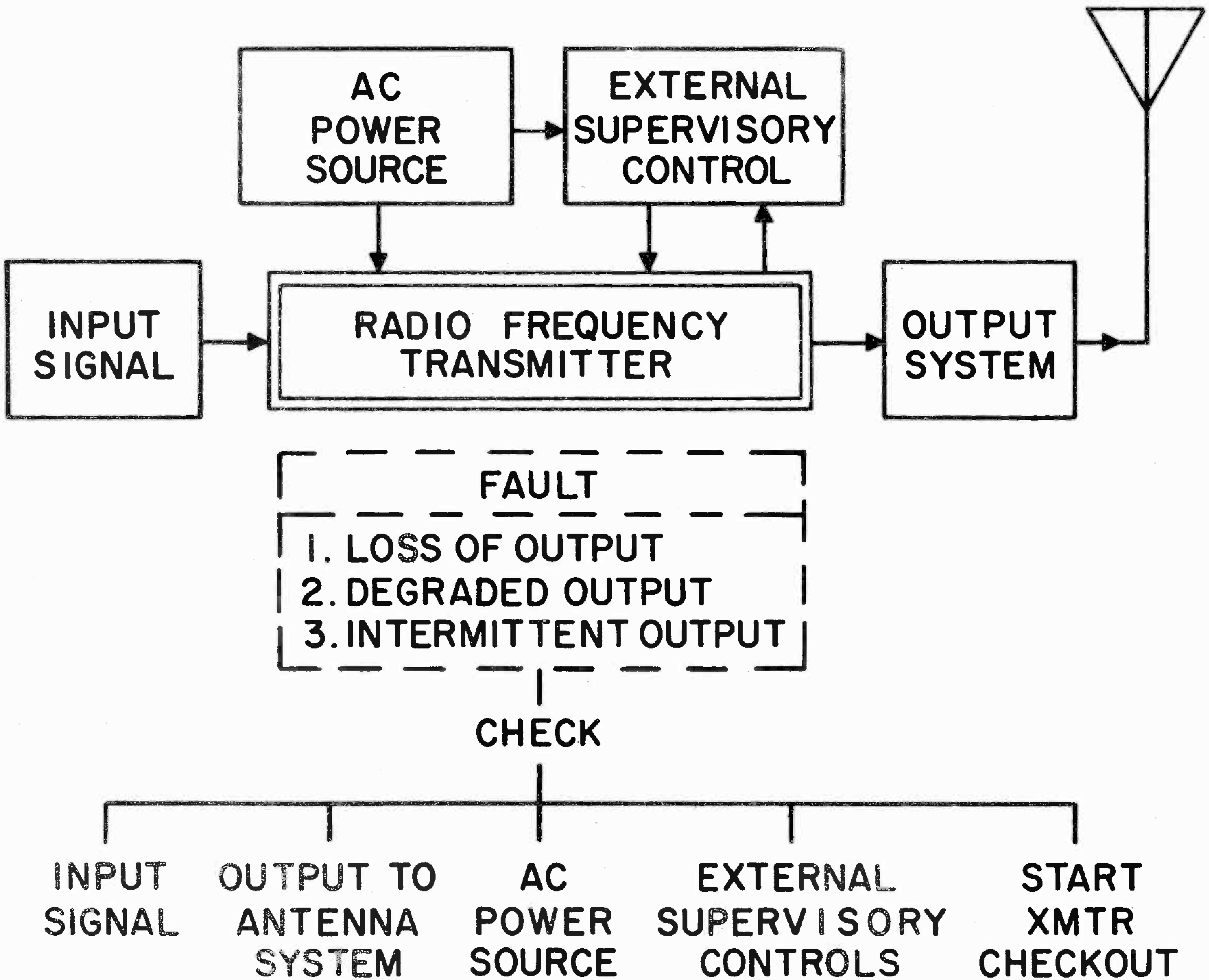

AC
POWER
SOURCE
EXTERNAL
SUPERVISORY
CONTROL
INPUT
SIGNAL
RADIO FREQUENCY
TRANSMITTER
OUTPUT
SYSTEM
FAULT
1. LOSS OF OUTPUT
2. DEGRADED OUTPUT
3. INTERMITTENT OUTPUT
CHECK
INPUT
SIGNAL
OUTPUT TO
ANTENNA
SYSTEM
AC
POWER
SOURCE
EXTERNAL
SUPERVISORY
CONTROLS
START
XMTR
CHECKOUT

Figure 2

Although this document basically covers transmitter fault isolation, the general concepts apply to any electronic system. Figure 3 illustrates both the generality of terms used, and how related circuits are adaptable to a generalized fault-isolation technique.

V. SUBDIVISION OF FAULTS WITHIN THE TRANSMITTER.

The initial subdivision of a fault within a transmitter is usually available from built-in metering. The formalized part of the procedure should include the reading of all metering available on the transmitter. It is extremely important to read all the meters and multimeters before making a decision. Stopping the meter reading procedure when the first suspicious indication is encountered must be discouraged.

A check of all fuses and circuit breakers are also part of the initial procedure. It is emphasized to make a complete check of all meters, fuses, and circuit breakers; however, it is not implied that fuse checks, meter checks, and circuit breaker checks cannot be interspersed.

Part of the development of the formalized procedure should be of a practical nature. Fuses should be removed individually and in groups, and the results noted. Circuit breakers should be tripped to simulate possible overloads and the significant results incorporated into the fault isolation procedure. Caution must be exercised in simulating these faults. Although fuses and circuit breakers are protective devices, their operation may cause contributory failures. For example, removal of a bias fuse may cause serious damage if a plate overload is defective. Therefore, check that the plate overload is operative before removing bias fuses for practical observation of faults. Figure 4 illustrates the major subdivisions within a transmitter.

In nearly all cases of interest, an intermediate point is established between two large blocks of circuitry and the question arises as to what indications are available to establish the location of the fault in either of these areas. If the fault does exist at the point being examined, it will be evidenced by the inability to determine exactly which component or area is defective. Thus it is relatively easy to isolate the fault to a given large area. However, the closer you come to the exact fault location, the more difficult it becomes to find the defective component.

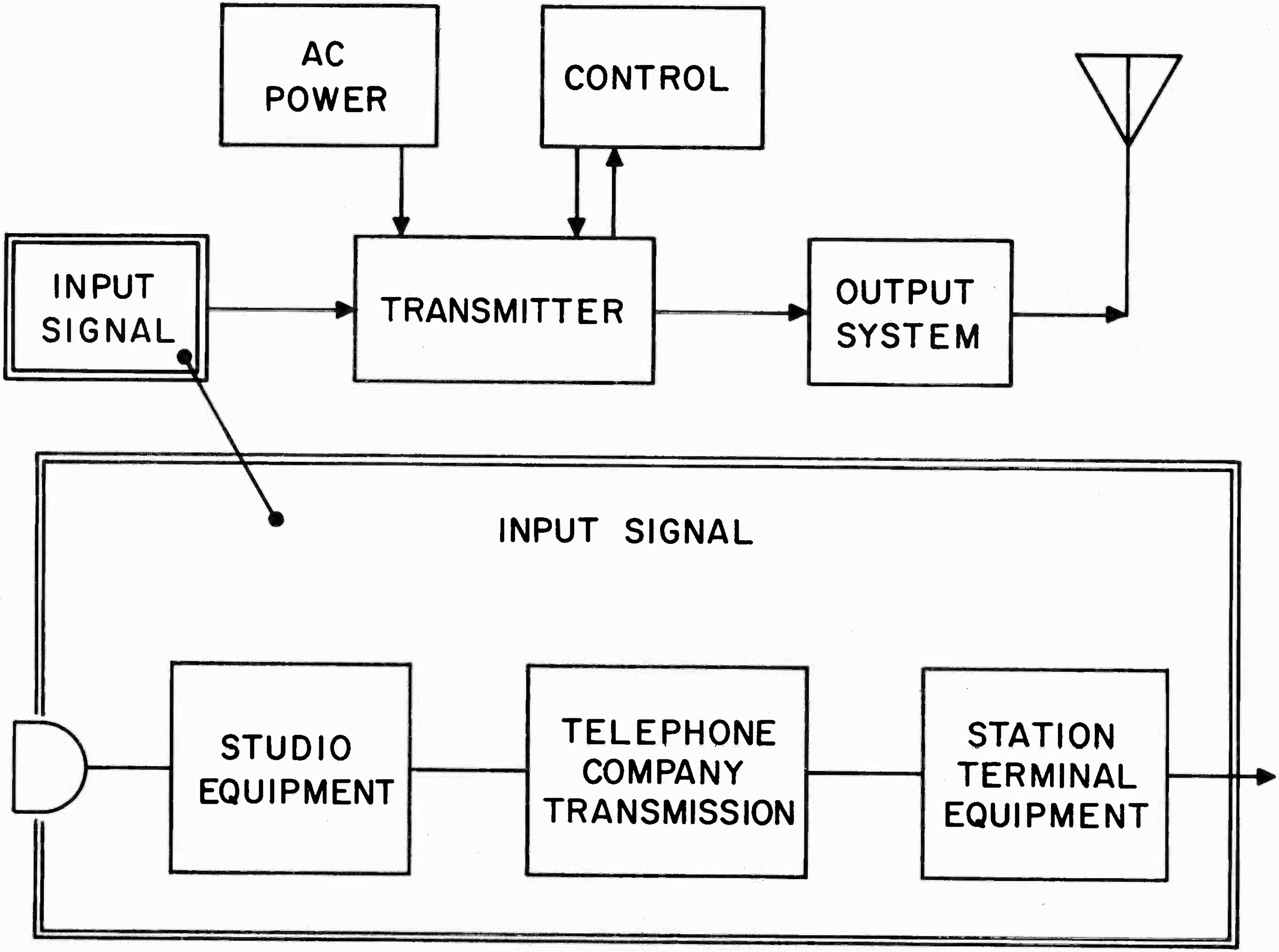


Figure 3
Page 8

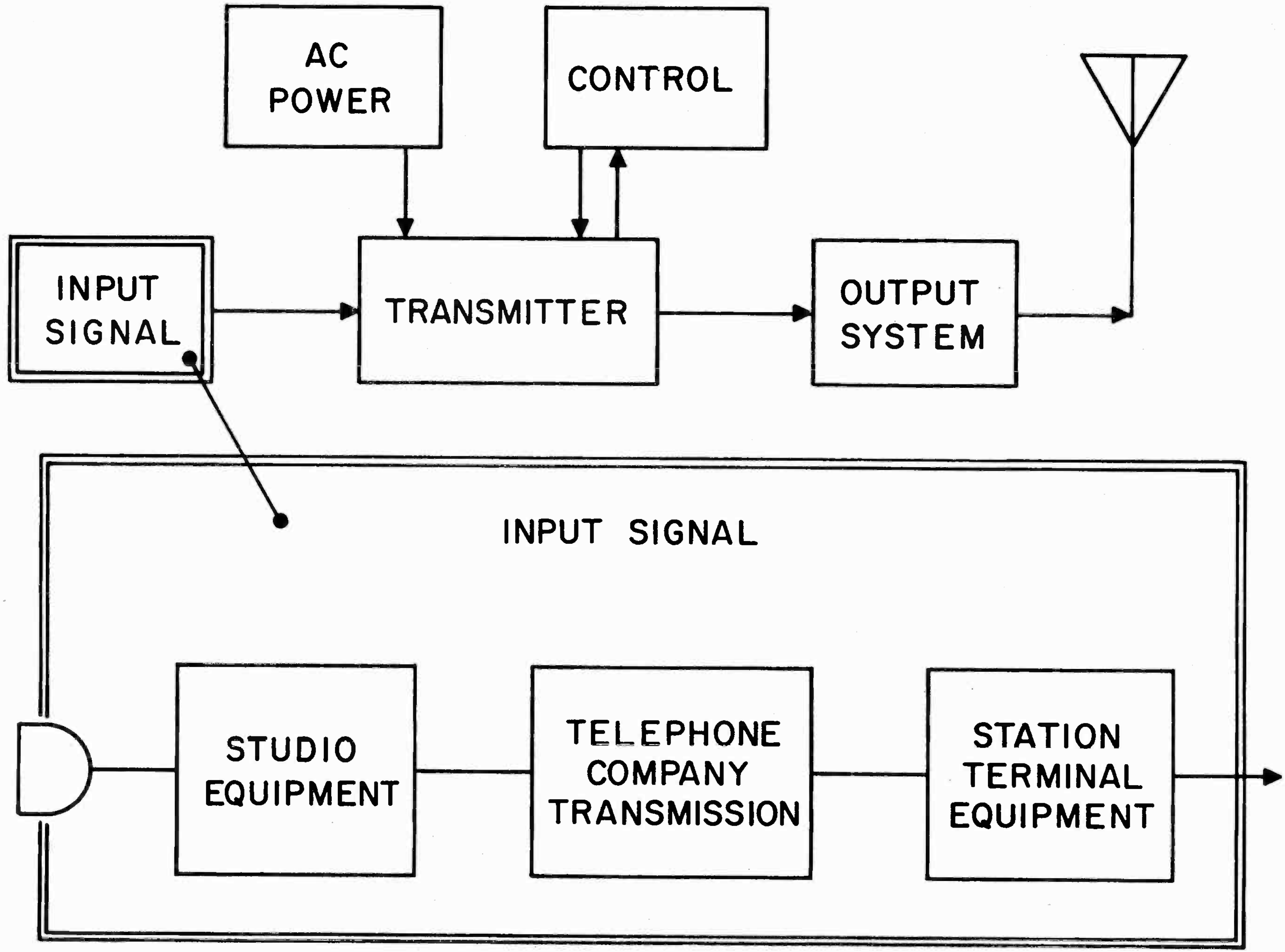
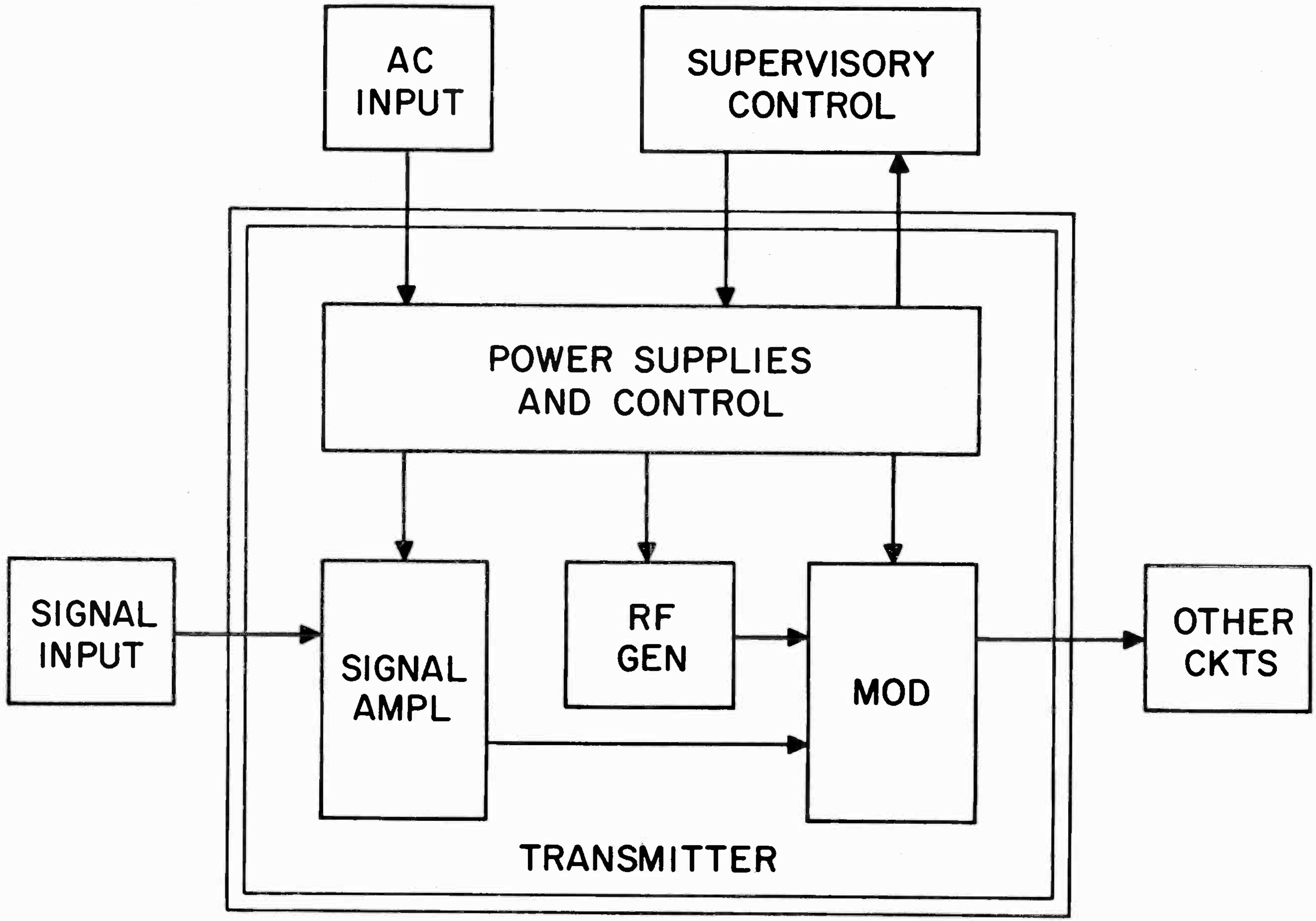


Figure 3
Page 8



TRANSMITTING SYSTEM

Figure 4
Page 9

It is at this point that the formalized fault-isolation procedure as described in this paper must end. The fault has been localized to a specific area. Up to this time, the transmitter was usually energized to help isolate the fault. As the location of the fault is localized, it becomes more difficult to be able to energize equipment as an aid to fault isolation. Generally speaking, the fault should be fairly well localized before interlocks and safety devices are tampered with. Thus the last stages of actually finding the fault must utilized a good deal of knowledge of how to discern a defective component in its unenergized state.

VI. HARD TO ESTABLISH FAULTS.

There are certain types of faults that are very difficult to evaluate. Several of these will be briefly discussed. These faults are usually intermittent in nature and can be easily confused with other types of faults. For example, an intermittent arc-over condition is similar in some respects to a parasitic oscillation.

(1) Instability or Oscillation - It is very difficult to establish the degree of stability of a transmitter in the field. The procedure usually followed by the equipment manufacturer in the design stage is as follows:

(a) built in feedback is removed

(b) gain is increased in all stages

(c) sensitive VTVM's are installed at all grids or plates of tubes

(d) the equipment is tuned to a typical frequency and terminated in a dummy load

(e) the r-f input is driven with a signal generator from 10 kc to at least 300 mc

(f) sufficient drive is used to establish definite indications on all VTVM's.

The interpretations of the stage gains of the above test will indicate degree of stability. The foregoing is applicable to both audio and r-f amplifiers.

(2) Feedback Stability - After the above listed stability tests are completed, the feedback stability can be checked. Normal or the maximum anticipated stage gains are established. Feedback is then increased until oscillation occurs. The maximum normal feedback is then established at a specified number of decibels below the point of oscillation. The proce-

dure must allow a margin of saftey for both tube and circuit variations anticipated over life of the equipment.

(3) Circuit Loading - Both amplifier and feedback circuits are effected by circuit loading. Feedback cannot be removed indiscriminately without regard to both a-c and d-c circuit loading. Also the determination of faults in an r-f amplifier must pay due respect to circuit loading of both the following-grid and plate circuits.

VII. TYPICAL EXAMPLE.

Figure 5 shows three stages of fault isolation. The top half combines two basic diagrams:

(1) The diagram used to establish that the fault is in the transmitter

(2) The diagram used to establish the fault to one of the large blocks of circuitry in the transmitter.

The lower half of figure 5 shows a succeeding diagram used to further subdivide the fault. This fault was the result of the grid series resistor changing resistance under load. Under periodic proof-of-performance test, this resistor caused increased distortion and finally the unbalanced drive would trip-out the overload at as low as 40 percent modulation. The defective resistor was found by heating it artifically with a hair dryer. Fortunately, a standby transmitter was available during the trouble shooting period.

VIII. CONCLUSION.

There is a need for a fault-isolation procedure. The big question is, who has the time to do it? Certainly the station operating personnel have more than the can do.

It is our belief that the job can be done by undergraduate engineering students employed on a summer-time basis. We have employed the services of some of these students to our mutual benefit. Careful selection and proper supervision of these students would enable them to get this job well on the way to completion.

Perhaps a suitable paper can be given next year by someone actually starting to formulate a fault-isolation procedure by employing summer-time undergraduates.

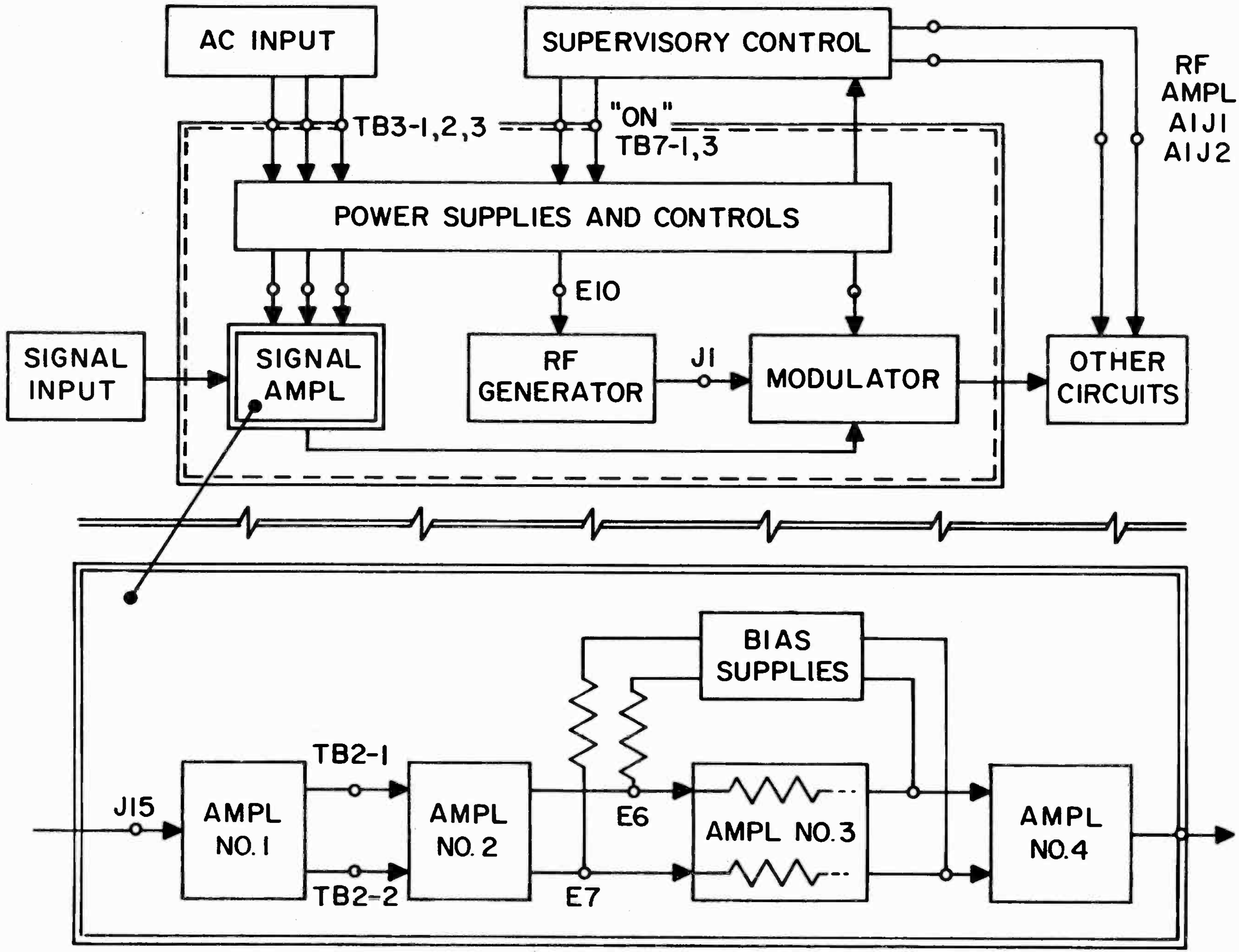

AC INPUT
SUPERVISORY CONTROL
TB3-1,2,3
"ON"
TB7-1,3
RF AMPL A1J1 A1J2
POWER SUPPLIES AND CONTROLS
E10
SIGNAL INPUT
SIGNAL AMPL
RF GENERATOR
J1
MODULATOR
OTHER CIRCUITS
BIAS SUPPLIES
TB2-1
TB2-2
J15
AMPL NO. 1
AMPL NO. 2
E6
E7
AMPL NO. 3
AMPL NO. 4

Figure 5

VTX Slow Motion Video Tape

A. W. Malang
Chief Video Facilities Engineer
American Broadcasting Company

NAB - 1962

During the course of the extensive and varied sporting event coverage by ABC within the past year, there had arisen many instances where the ability to expand the timing of an event for a closer analysis would have been an asset. At the request of the Program Department, a study was made to determine how such a process could be evolved.

The obvious place to start such a study was with slow motion film; however, direct film shooting was immediately ruled out for a variety of reasons, not the least of which was the burden of double coverage.

The possibility of using kinerecording as the film mechanism was examined and the following deficiencies appeared:

1. Either the film should run fast originally and normal on play-back, or normal on exposure and slow on play-back, each method necessitating substantial mechanical modifications.

2. The fast processing of film is at best a difficult process.

3. A separate recording just for slow motion would have to be made except in the case of slow play-back.

While it was known that a rapid viscous processor would soon be available, and the design of a commercially available non-intermittent projector seemed to lend itself to variable speed operation, the system appeared to be complex, costly, and of dubious reliability and speed.

At this point, a more wide searching approach was taken to examine the state of the art. Inquiries into the data processing area revealed that real time was used during recordings but that frequency translation (time expansion or compression) was widely used on play-back. This in turn led to the concept of Video Tape recording as the mechanism for time expansion. An examination of the hypotheses of television magnetic tape recording supported the thesis. Replies from equipment manufacturers and allied enterprises were negative, and as is so often the case with Broadcasters, what cannot be obtained is built. A feasibility study was made, a feasibility model assembled, and the performance evaluated.

The procedure followed which gave us slow motion Video Tape was simplicity itself; the recording is made in the normal manner and, on play-back the machine is run at half speed, yielding a two-to-one time expansion (very close to the 2.25 used extensively with film). The signal from the tape machine must then be standards converted before being rebroadcast.

As an introduction to the conversion of the tape machine, an examination of the key parameters of the signal and servo circuits serves to orient one to the modifications that must be undertaken. This is seen in the attached tabulation (3a).

From this, one can deduce that almost every chassis in the play-back channel must be modified; however, strangely enough, the total amount of modification is not as tremendous as one would first guess. In the case of the first unit modified at ABC, a very substantial simplification was achieved by using a machine equipped for multi-standard operation (inter-switch), hence one more standard was added to its complement.

Examination of the servo circuitry reminds one that the most serious complexity lies in the drum servo. If one attacks the problem with logic instead of gusto, it is soon apparent that the harmonic relationship of the two modes permits one to add a doubler and a divider only, instead of wholesale rebuilding. Certainly such a procedure is highly desirable, particularly since it permits one the luxury of simple switching between modes.

The other area where logic was important was in the motor drives themselves. Running synchronous motors from feedback amplifiers at two widely separated frequencies can be fraught with all kinds of difficulties unless great care is exercised with regard to phase. Most of the pitfalls can be sidestepped if one impedance (power factor) corrects the load, and when this is done the total modification reduces again. (See diagram, Motor Drive System).

The remainder of the modifications required little more than routine design, being for the most part RC phase shifter changes or pulse wideth time constant changes for regenerative stages. Even the demodulator was simply a case of doubling the delay for a quadrature type detector.

The standards converter has been described in detail previously;[1] however, it can best be briefly summarized as a vidicon camera channel looking at a projection kinescope. It's sole purpose in this project is to convert the time base back to 525 line 60 field broadcast standards.

The overall system performance is difficult to describe quantitatively since the output signal is directly related to the input parameters and the interaction thereof. However, some judgment can be made from the photographs appended hereto. These are representative.

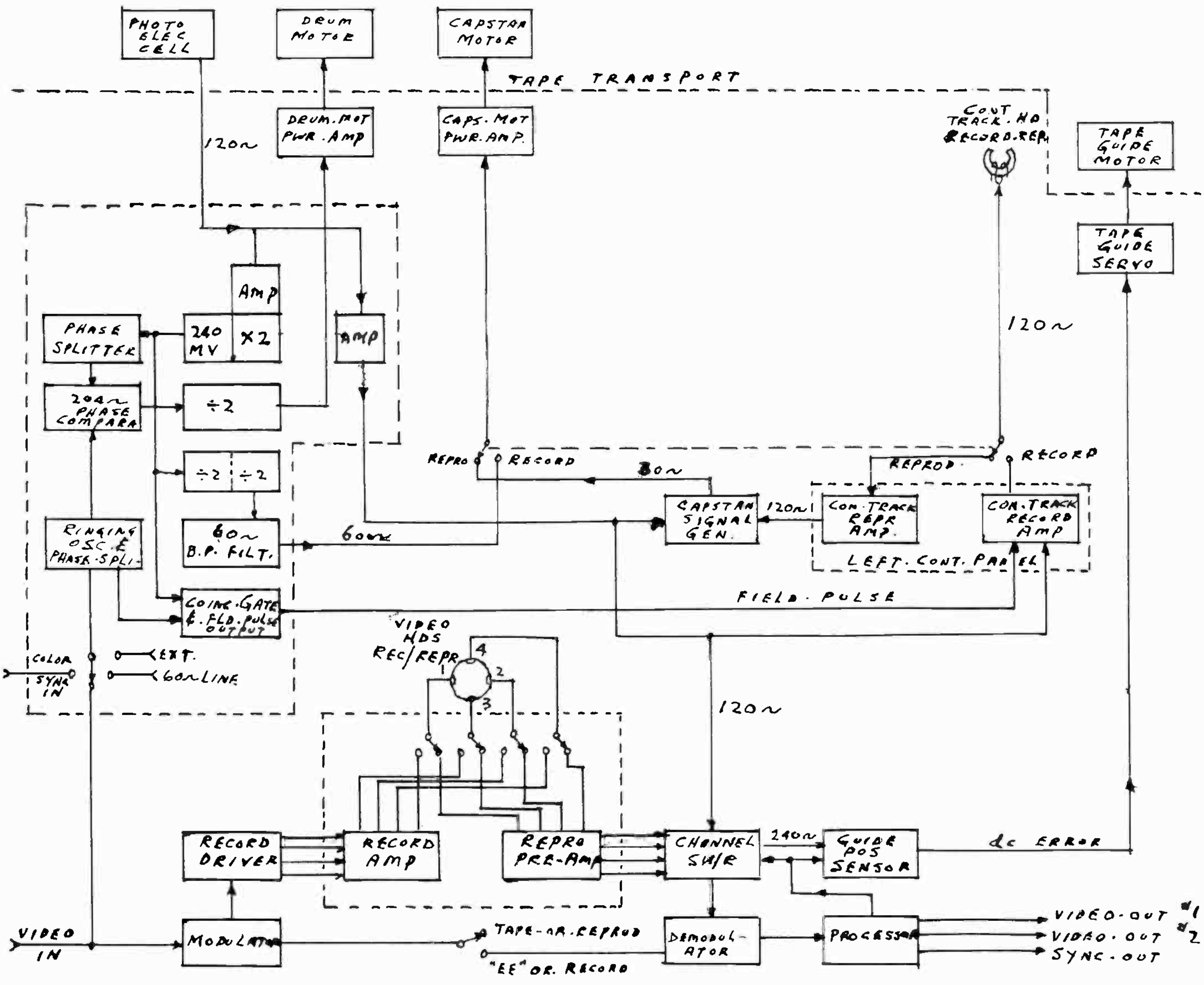
Then, then, is the tool which has been used over many months of 1961 and 1962 to add to the enjoyment of many sporting events.

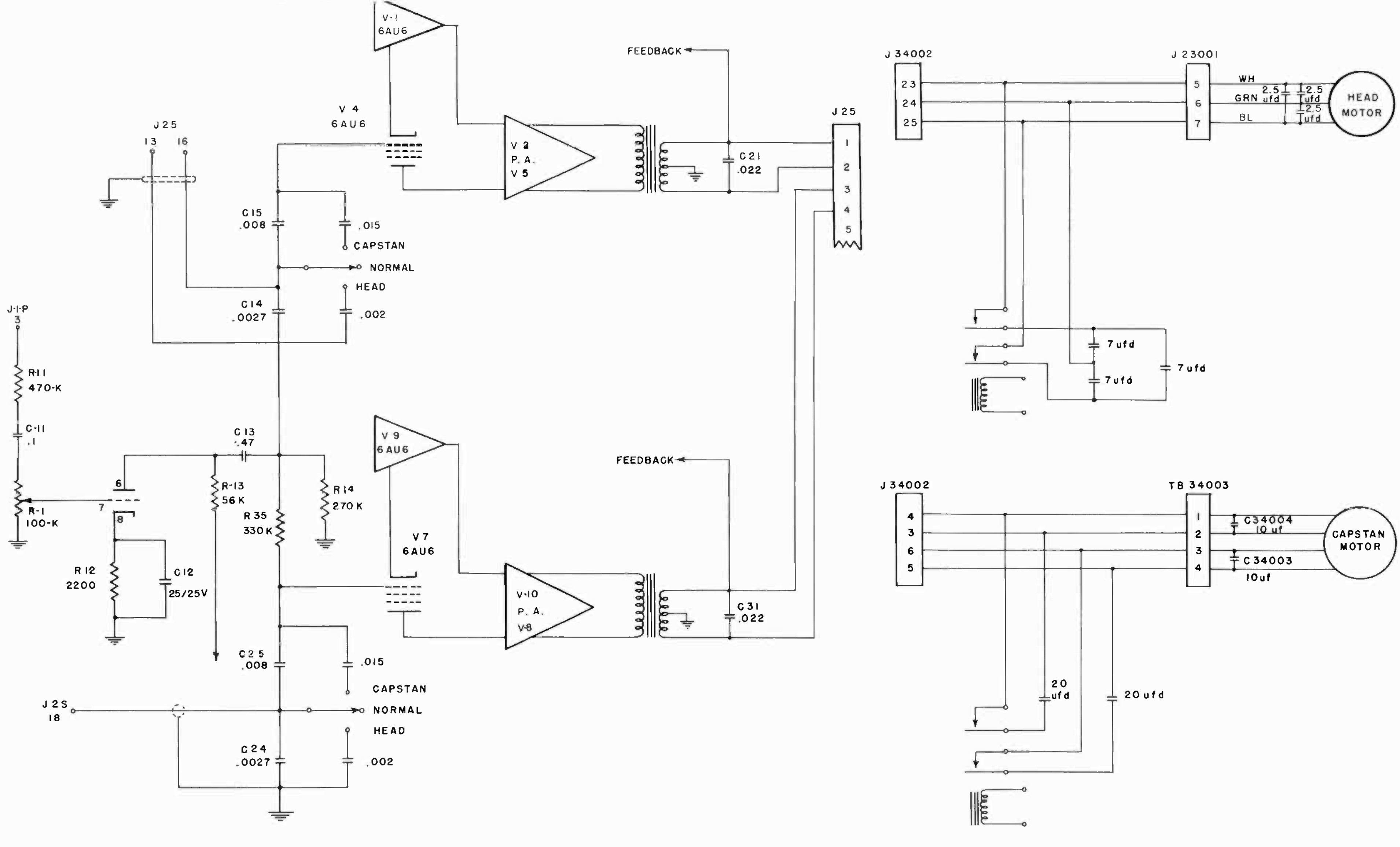
[1] IRE PGB Transactions

Specifications: Key Parameters

ITEM	SLOW MOTION	STD
FM Peak White (100 IRE)	3.4 mc	6.8 mc
Blanking (0 IRE)	2.5 mc	5.0 mc
Sync (-40 IRE)	2.15 mc	4.3 mc
Bandwidth Filter	2.4 mc	4.2 mc
Line Freq.	7875 cps	15,750 cps
Frame Freq.	15 cps	30 cps
Line Blanking	22 us	11.2 us
Line Sync	6 us	4.8 us
Field Blanking	21 lines	21 lines
Head Drum Freq.	120 cps	240 cps
Capstan Freq.	30 cps	60 cps
Control Track	120 cps	240 cps
Head Switching Freq.	120 cps	240 cps

BLOCK DIAGRAM
VTX · SLOWMOTION · PROJECT





MOTOR POWER AMPLIFIERS
CATALOG # 50750

TAPE TRANSPORT ASSEMBLY
CATALOG # 50533

MOTOR CIRCUIT MOD.

VTX—SLOW MOTION PROJECT

BY	DATE	REVISION	LETTER

AMERICAN BROADCASTING COMPANY
ENGINEERING DEPARTMENT
NEW YORK, N. Y.

FIRST MADE FOR—
ENG. PROJECT NO.—
SCALE—

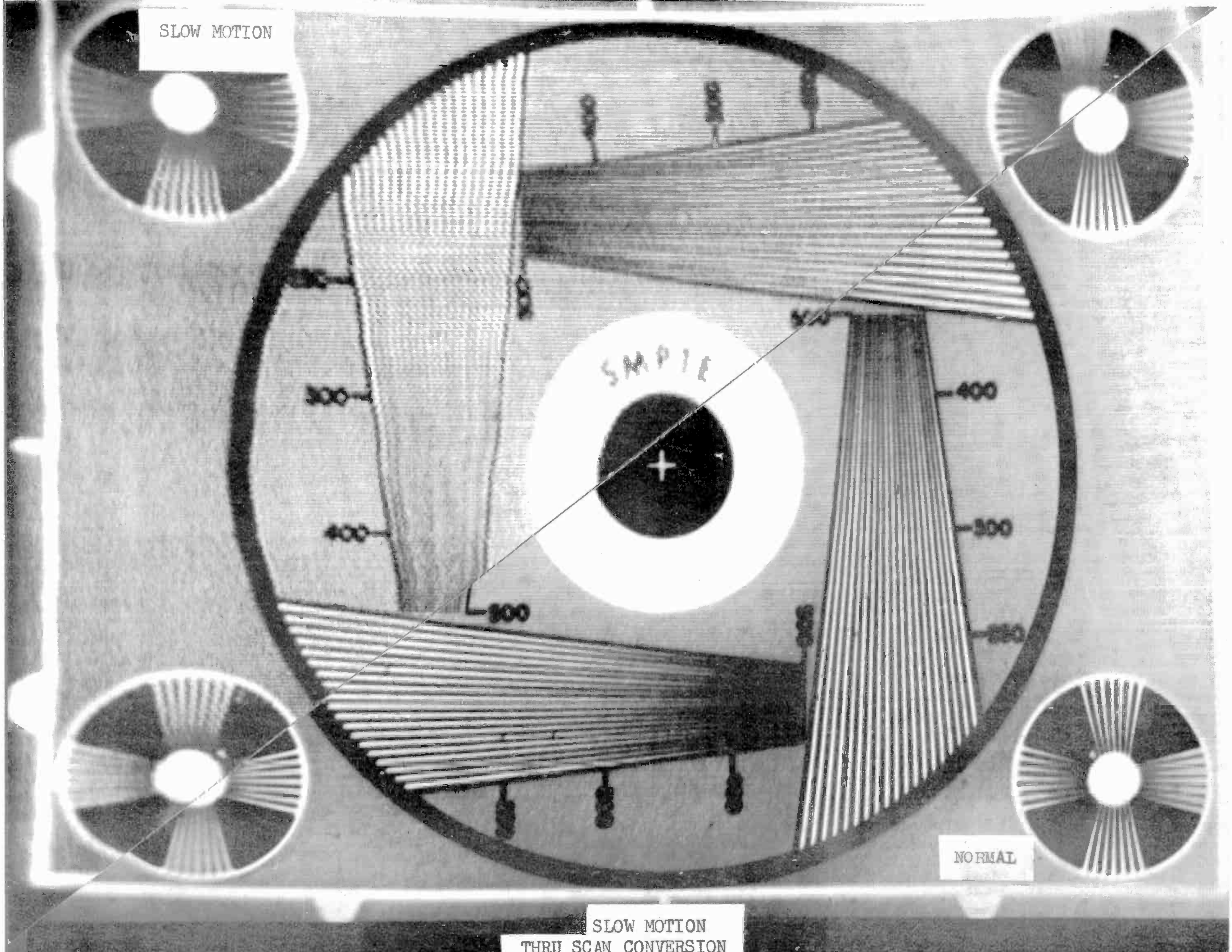
DRAWN BY—	DATE—
CHECKED BY—	DATE—
APPROVED BY—	DATE—
APPROVED BY—	DATE—

W-

W-


SLOW MOTION
THE FLINTSTONES
NORMAL
SLOW MOTION
THRU SCAN CONVERSION


SLOW MOTION
NORMAL
SLOW MOTION
THRU SCAN CONVERSION


SLOW MOTION
300
400
800
500
400
300
NORMAL
SLOW MOTION
THRU SCAN CONVERSION

RDP-199

A SOLID-STATE DIRECT FM SYSTEM
FOR MONO, STEREO, AND SCA BROADCASTING

Prepared by
Robert J. Hirvela
and
Frank D. McLin

COLLINS RADIO COMPANY

Cedar Rapids, Iowa

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A SOLID-STATE DIRECT FM SYSTEM
FOR MONO, STEREO, AND SCA BROADCASTING

Section I
ADVANTAGES AND RELIABILITY OF TRANSISTORS

For many years the vacuum tube has been the basic active element in broadcast equipment designs and until recently the transistor has not been utilized extensively. One of the main reasons for the relatively limited use of transistors has been their cost. However, as the semiconductor art has developed, prices have been decreasing continually. Today, germanium transistors cost about the same as vacuum tubes, and silicon transistors are slightly higher. The advantages of the transistor are its small size, light weight, high reliability, lack of heater circuits, and high efficiency.

Because off-the-air time is costly, the advantage in reliability is of primary importance to the broadcast industry. To provide some idea of how transistors compare in reliability to other components, table 1 lists the failure rate in order of decreasing reliability of various components.

TABLE 1. RELIABILITY COMPARISON

COMPONENT	FAILURE RATE %/1000 HR
Tubes, Power (Xmtr)	5.00
Motors, Servo	0.64
Tubes, Octal and Miniature	0.47
Meters	0.22
Relays	0.15
Crystals	0.10
Capacitors, Variable	0.10
Transformers, Coils and Reactors	0.04
Transistors, Germanium	0.035
Resistors, Variable	0.033
Capacitors, Electrolytic	0.033
Transistors, Silicon	0.032
Diode, Germanium	0.025
Diode, Silicon	0.022

These data are utilized by the Reliability Department of Collins Radio Company to estimate the expected mean-time-between-failure (MTBF) of fixed ground station radio equipment. Notice that transistors are approximately 13 times more reliable than the miniature or octal tubes which they usually replace. This does not imply that transistorized equipment will be 13 times more reliable than its vacuum-tube counterpart because the reliability of all components must be considered. However, because transistors operate at a much lower temperature than vacuum tubes, other components usually are subjected to lower ambient temperatures. As a result, their reliability also tends to increase somewhat.

Section II

COMPATIBLE FM STEREO

The FCC approval of a stereo multiplex system was one of the most significant developments which affected the broadcast industry during 1961. The system is capable of providing excellent stereo broadcasts but requires equipment having higher performance capabilities than monaural FM equipment. To provide the required high performance with reliability, a new solid-state stereo generator and FM exciter have been designed for monaural, stereo, and SCA broadcasting.

The stereo generator uses the time division multiplex approach to provide the entire stereo signal as a single output with a frequency range from 30 to 53,000 cps. The FM exciter utilizes a solid-state, broadband, direct FM modulator which accepts the broadband input and produces full deviation at 14 mc. A solid-state automatic frequency control system references the 14-mc carrier frequency to a crystal standard. The resultant modulated signal is translated to the assigned carrier frequency and amplified to a 10-watt power output using five vacuum tubes. Because of the 10-watt output required of the exciter, it was not advisable economically to utilize transistors in this part of the exciter.

Section III

FM STEREO SYSTEM REQUIREMENTS

Before describing the stereo generator and exciter in detail, some discussion of the system requirements for FM stereo is in order. From this discussion, the advantages of the broadband direct FM technique should become apparent.

The specifications for the FCC stereo multiplex system are contained in the appendix to FCC Docket 13506. Basically, the specifications require that the main FM channel be modulated with a signal obtained by adding the left and right channel signals and that a 38-kc double sideband subcarrier be modulated with a signal obtained by subtracting the left and right channel signals. A 10-percent modulated 19-kc pilot carrier with zero crossings simultaneous with the 38-kc subcarrier also is required to provide a phase reference for demodulating the DSB. The spectrum of the composite signal is shown in figure 3-1.

The FCC requires that the channel separation must be 29.7 db for modulating frequencies from 50 to 15,000 cps. Crosstalk between the (L+R) and (L-R) channels must be more than 40 db down. The remaining specifications are essentially the same as the existing FM broadcasting specifications.

Of these specifications, the 29.7-db channel separation specification is the most critical. This requires, for an input into one channel only, that the (L+R) audio and (L-R)

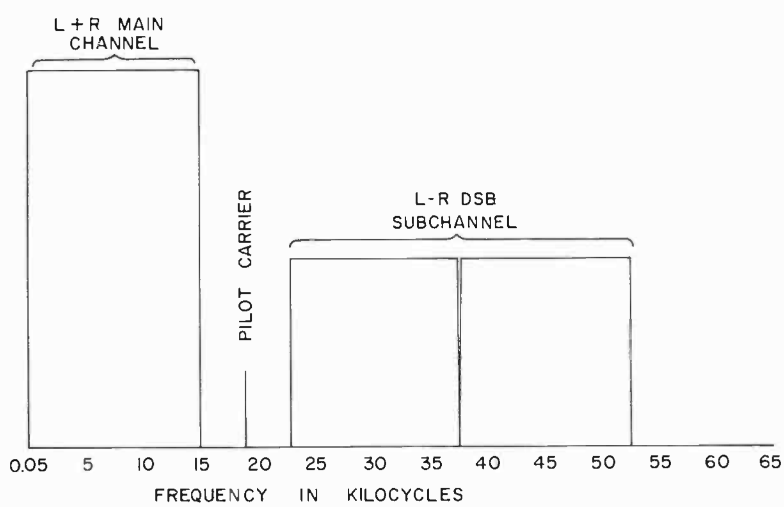

Figure 3-1. Spectrum of Complete Stereo Signal (Relative Amplitudes Based on Signal in One Stereo Channel Only)

DSB signals in the transmitter output have equal amplitudes within 3.5 percent (0.3 db) and that the zero crossings of the DSB envelope and the (L+R) signal occur simultaneously within ±3 degrees. In terms of system performance, this requires that the main and subchannel circuits have gains which are equal within 0.3 db and have time delays which are equal within 3 degrees at any modulating frequency between 50 and 15,000 cps.

Section IV

COMPARISON BETWEEN PM AND DIRECT FM FOR STEREO

In order to illustrate clearly the advantages of direct FM for stereo broadcasting, it is useful to discuss a typical phase modulation (PM) system and how it might be used for stereo broadcasting. An example of a phase modulator is shown in figure 4-1. As used for normal FM broadcast, this type of modulator is quite well known and needs no explanation. There are two basic ways in which it might be considered as a modulator for FM stereo broadcasting.

The simplest apparent way would be to apply the composite stereo signal of 50 to 53,000 cps to the modulator input. When this scheme is analyzed, it is found that there are two severe factors which make it unworkable.

(1) The frequency multipliers would not be able to handle the wide-band signal with adequate response and still suppress the unwanted spurious due to the low fundamental frequency of 102 to 125 kc.

(2) The corrector network required to give a frequency modulation characteristic to the phase modulator could not have adequate amplitude and phase linearity for the wide-band signal without a serious sacrifice in signal-to-noise ratio at the high end.

Another way in which the phase modulator might be used for FM stereo is shown in figure 4-2. In this technique, the left and right channels are combined in a matrix circuit to obtain an (L+R) signal and an (L-R) signal. The (L+R) signal is applied to the main

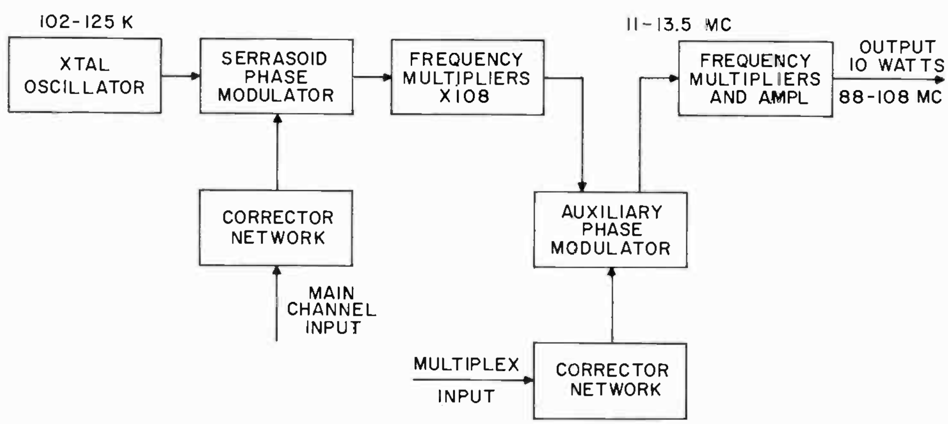

Figure 4-1. Typical Phase Modulation System

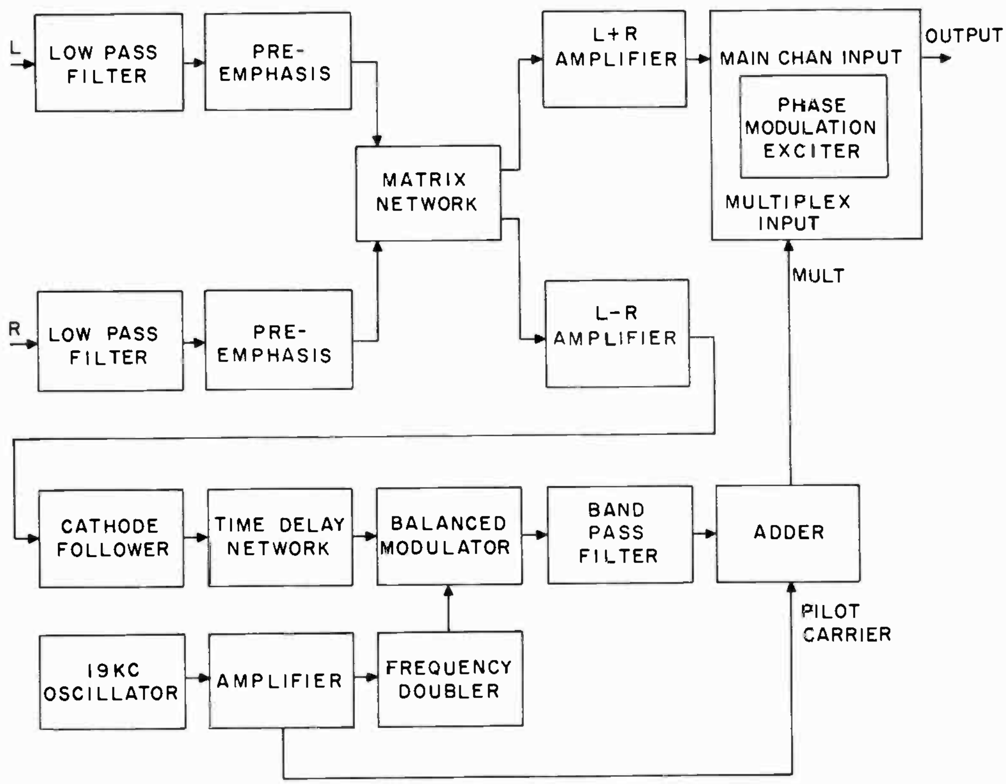

Figure 4-2. Matrix Stereo System with Phase Modulator

channel modulator. The (L-R) signal is DSB modulated onto a 38-kc carrier and this DSB signal is fed through a time delay network, a corrector network, and into a phase modulator to modulate the carrier. The carrier applied to this modulator already has the main channel (L+R) modulation on it and is in the frequency range of 11 to 13.5 mc.

This technique obviously is complicated and to make it work satisfactorily requires very careful design and adjustment of the circuits.

Because of the time delay through the tuned circuits in the frequency multipliers, it is necessary to insert a compensating time delay in the path of the (L-R) signal. It is essential that all of the critical circuitry be very stable in order to maintain channel separation over a long period of time without readjustment. The number of critical components contained in this circuitry is rather large and a small change in any of them could cause the equipment to fail to maintain a 29.7-db channel separation. The significant components involved in the critical path would be two corrector networks, two phase modulators, five frequency multiplier stages, and any amplifiers which might be used in the (L+R) and (L-R) channels. This circuitry typically would contain a minimum of nine active elements and 15 adjustable coils. Due to the great number of components in the critical circuitry, such a system would require frequent adjustment. Replacement of any of the critical components would necessitate readjustment of the system for channel separation. Note that the critical components are in both the exciter and the stereo generator.

When the PM system is compared with the direct FM system, the greatest advantage of the direct FM system becomes readily apparent. The PM system described above has many elements in which a small change could cause the channel separation to fall below 29.7 db, while the direct FM system contains only a few resistors in the stereo generator which could have such an effect. The complete stereo signal is generated together and transmitted through the exciter without ever separating the main channel from the stereo subchannel. Therefore, there is no need for matching the amplitude and phase response of separate signal paths.

Section V

TIME DIVISION STEREO GENERATOR

There are two basic methods for generating the stereo signal, matrixing and time division. The matrixing system was utilized in early phase modulator stereo systems. These systems require that the (L+R) and (L-R) DSB signals be provided as separate inputs to the exciter. The matrixing system provides a two-wire output, while the time division technique inherently provides the composite signal as a single output. With the Collins modulation system, the entire signal is applied to a single input on the modulator and the time division technique provides a simple and reliable system.

It can be shown mathematically that the spectrum required of the composite stereo signal is contained in the output of a switch which switches alternately between the left and right channels. To make the signal exactly identical to that required by FCC specifications, it is only necessary to add series and shunt resistors to equalize the amplitudes of the main and subchannels, and to filter the unwanted high frequency components.

Figure 5-1 is a photograph of the Collins stereo generator and its block diagram is shown in figure 5-2. It utilizes either transistors. Basically, the circuit operates as follows: The balanced 600-ohm left and right channel inputs are connected to plug-in pre-emphasis networks. The output of the networks is connected to balanced 600-ohm input transformers. The transformers also serve as 30-cps high-pass filters to provide attenuation for subaudio frequency components which may be present in the input. This attenuation prevents subaudio frequency interference with the frequency stabilizing circuits. The transformer-filters are connected to low-pass filters which attenuate any audio components above 15 kc. This eliminates high-frequency components in the audio input which would otherwise produce crosstalk or interference with the pilot carrier. The filter outputs are connected to emitter follower amplifiers which provide isolation between the channels and drive the stereo switching circuit. The diode switching circuit alternately samples each channel at a 38-kc rate and generates the composite stereo signal. As with all switching modulators, the switching circuit output contains DSB signals about the odd harmonics of the 38-kc carrier. The switch output is connected to a low-pass linear phase filter which removes these sidebands. This filter has a constant time delay for all frequencies from 30 to 53,000 cps to maintain the stereo channel separation. The output of the filter then is connected directly to the broadband exciter input.

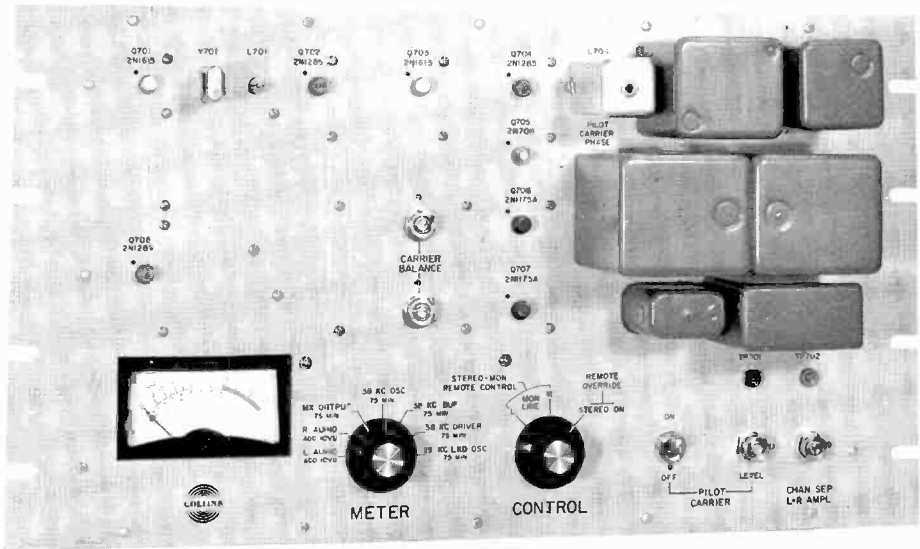

Figure 5-1. Stereo Generator

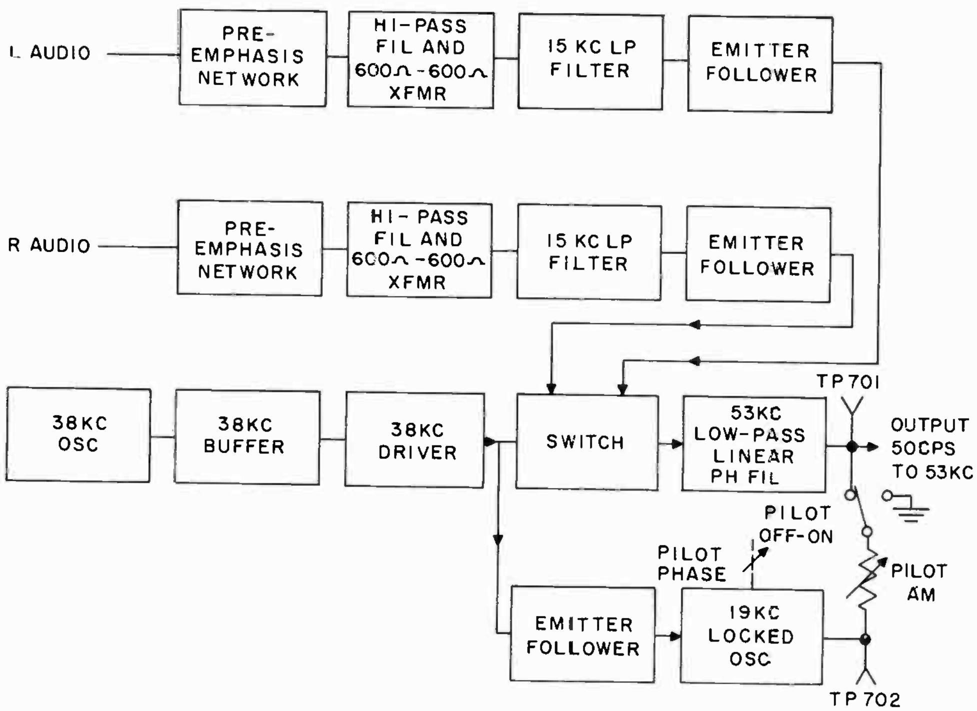

Figure 5-2. Stereo Generator, Block Diagram

The 38-kc driving signal for the switch is obtained from a 38-kc crystal oscillator and two-stage driver. The 19-kc pilot carrier is obtained by dividing the frequency of this driving signal with a locked oscillator. The locked oscillator output is added to the stereo signal at the output of the linear phase filter.

The stereo generator is capable of maintaining stereo channel separation considerably in excess of the FCC specifications for a long period of time. This is possible because after the stereo signal is generated, the entire signal is handled by the same passive circuits.

The stability of the pilot carrier phase is determined only by the locked oscillator tuned circuit. Phase shifts in the 38-kc buffer and driver have no effect on the pilot carrier phase with respect to the subcarrier because the phase of the switch driving signal and locking signal to the pilot oscillator will be shifted by the same amount. The locked oscillator tuned circuit is temperature stabilized to maintain the correct pilot carrier phase over a wide temperature range.

The stereo generator has switching circuitry to permit remote switching from stereo to monaural operation. The audio input, 38-kc driver circuits and generator output are metered to facilitate maintenance. These features are not shown in the block diagram.

Section VI

DIRECT FM EXCITER

A photograph of the direct FM exciter is shown in figure 6-1. The exciter includes a power supply, modulator, afc circuit, a vhf mixer, and a vhf amplifier. It utilizes 20 transistors and five tubes. A block diagram is shown in figure 6-2. The exciter is capable of accepting a 30- to 75,000-cps input signal. This could be a monaural signal with two SCA channels or a stereo signal with one SCA channel. A separate input jack is provided for SCA.

6.1 FM MODULATOR.

The block diagram of the FM modulator is shown in figure 6-3. The heart of the modulator is a 14-mc LC oscillator which is frequency modulated by use of a voltage-variablé-silicon-capacitor (Varicap). In order to reduce distortion, the FM oscillator is enclosed in a feedback loop. The operation of the feedback loop is described in the following.

The 14-mc output of the oscillator is passed through limiters to remove any incidental AM and the limited signal is applied to an ultralinear 14-mc frequency discriminator. This discriminator is approximately 2 mc wide so that a few kilocycles drift or mistuning of the discriminator will have no effect on linearity. The output of the discriminator is an exact duplicate of the modulation which is being transmitted. This signal is a-c coupled to a comparator circuit where it is compared with the 30- to 75,000-cps input signal. The output of the comparator is equal to the instantaneous difference between the input signal and the output modulation. Stated another way, it can be said that the output of the comparator is an error signal indicating the error in the modulator. This error signal then is amplified in the baseband amplifier and applied to the Varicap-modulator to correct the modulator error.

The Varicap modulator has an inherent distortion of approximately 2 percent with the feedback loop open. The basic reason for the feedback loop is to reduce this distortion. In this system, it was decided that the optimum value of feedback ratio would be 10 to 1. Theoretically, this could reduce the 2-percent distortion to .2 percent if the limiters, discriminator, and baseband amplifier were perfect. In actuality, due to discriminator nonlinearity and residual noise, the measured distortion is approximately .4 percent. In addition to the reduction of modulator distortion, the feedback loop provides a proportionate reduction in incidental FM and variation of the amplitude and phase response of the modulator. The FM noise is 68 db down.

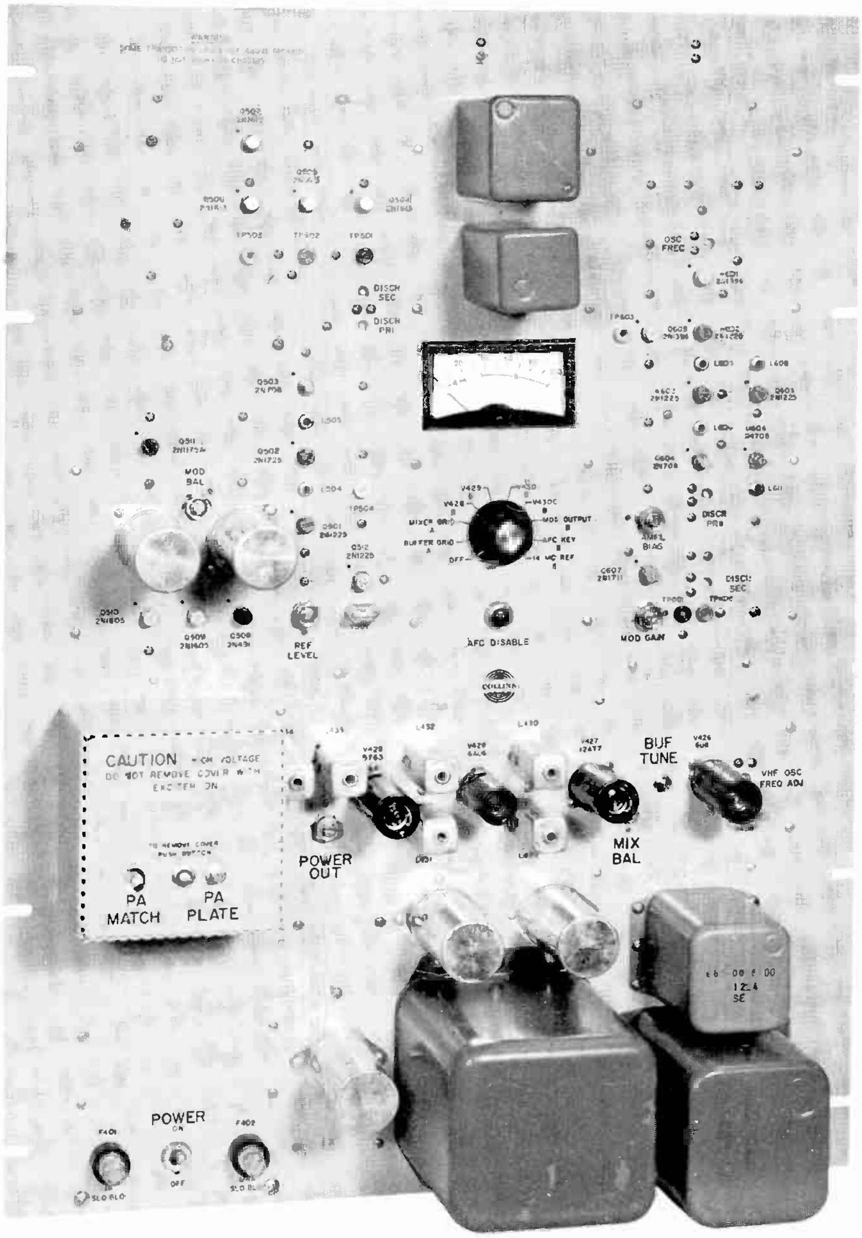

Figure 6-1. Direct FM Exciter

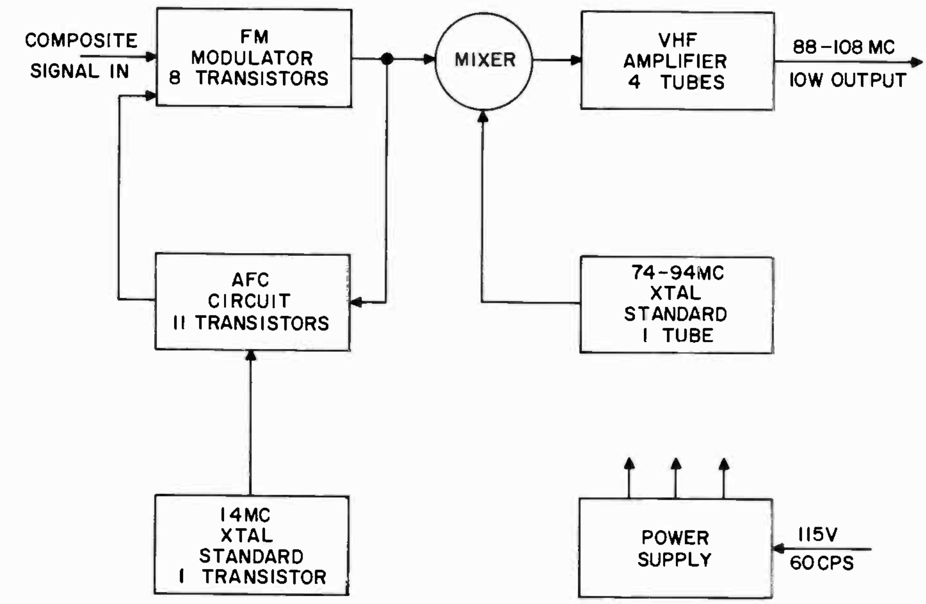

Figure 6-2. Direct FM Exciter, Block Diagram

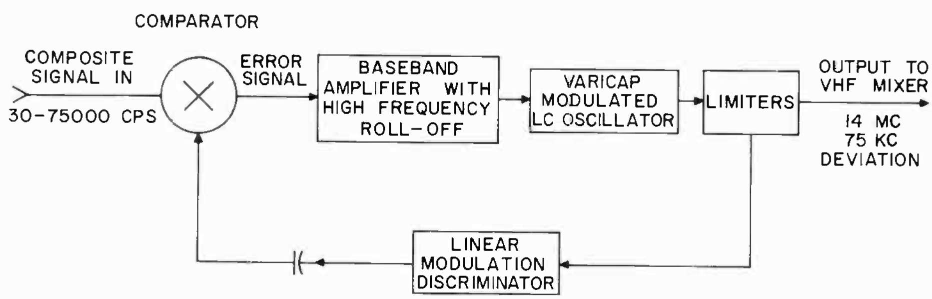

Figure 6-3. Direct FM Modulator, Block Diagram

The bandwidth required of the modulator is very great in comparison with that required for monaural FM broadcasting. In order to make certain that this modulator could have no effect on stereo channel separation, the 3-db frequency response extends from .5 cps to 800,000 cps. These upper and lower cutoff frequencies are determined by the modulator feedback ratio and the RC coupling circuits.

By designing the modulator with very wide frequency response and low distortion, we have ensured that the high channel separation capability of the stereo generator is not degraded in the process of modulation.

6.2 FREQUENCY CONTROL SYSTEM.

The automatic frequency control is an integral part of the complete modulator. As illustrated in figure 6-2, the afc provides a means of controlling the frequency of the 14-mc modulated LC oscillator by referencing it to a 14-mc crystal standard. The final carrier frequency is determined by the sum of the frequencies of the two crystal standards provided. All exciters use an identical 14-mc crystal mounted in a glass holder for improved aging characteristics. When the exciter is tuned to an assigned station frequency, the correct crystal is used in the vhf oscillator to translate the modulated signal to the correct assigned frequency. The vhf crystal is a precision fifth overtone unit mounted in a glass holder. The exact crystal frequency depends on the assigned channel frequency and is between 74 and 94 mc. Neither crystal requires a temperature controlled oven. The over-all carrier frequency stability for ±10 percent line voltage and 10°C to 55°C temperature variation is within 500 cps. This is well within the FCC limit of 2000 cps.

A block diagram of the afc system including the modulator is shown in figure 6-4. The afc operates to keep the carrier frequency equal to the frequency of the 14-mc frequency standard. The modulator output signal is applied to the afc comparator switch. The comparator is an electronic switch which operates at approximately 5 cps to switch alternately between the 14-mc frequency standard and the modulator signal. The output of the comparator switch is applied to limiters to remove any 5-cps amplitude modulation which might be present due to amplitude difference between the standard 14 mc and the modulator output. The output of the limiters then is frequency modulated by the amount of error in the modulator signal. That is, if there is no error in the modulator frequency, the limiter output is exactly equal to 14 mc. When an error exists, the limiter output shifts in frequency at a 5-cps rate between 14 mc and the actual modulator frequency. When this signal is applied to the wide-band frequency discriminator, the result is a 5-cps square wave whose amplitude is proportional to the modulator center frequency error. This 5-cps error signal is amplified in the 5-cps amplifier and applied to the synchronous detector. The synchronous detector converts the 5-cps a-c signal to a d-c voltage, which is proportional to the

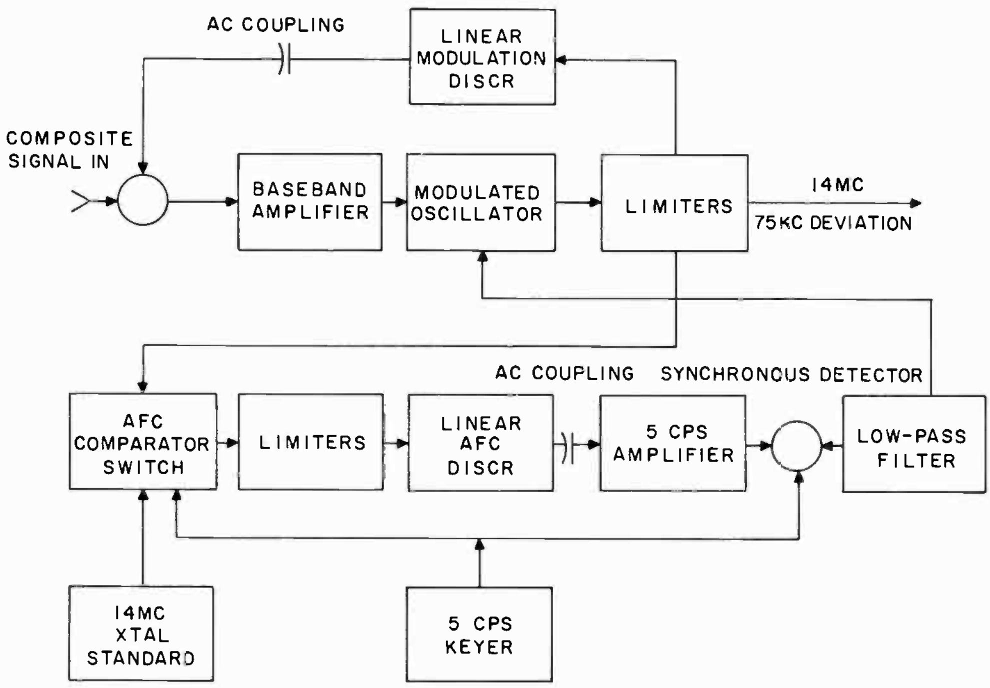

Figure 6-4. AFC System Including Modulator, Block Diagram

modulator frequency error and of the correct polarity. This d-c error signal is passed through the low-pass filter and direct coupled to the Varicap to reduce the carrier frequency error.

The comparator switch and the synchronous detector are driven synchronously by the 5-cps keyer.

The afc corrects for shift of the modulated oscillator average frequency due to any cause. Since the modulator feedback loop is a-c coupled only, the internal distortion of the modulator would cause a carrier shift under steady tone modulation if no afc were used. The afc, however, prevents this carrier shift. The high-frequency response of the afc feedback loop and the low-frequency response of the modulator loop overlap slightly in order to prevent transient carrier shift under modulation.

The most important feature of this afc system is that the discriminator center frequency tuning is not critical. It is only necessary that the afc discriminator have sufficient bandwidth and linearity to detect the 5-cps error signal in the presence of modulation and discriminator drift. The d-c output from the discriminator is determined by its center frequency tuning, but the d-c component is discarded when the signal is a-c coupled into the

5-cps amplifier. Like the modulation discriminator, the linearity of the discriminator is extremely important. Any even order distortion in the afc discriminator would cause a carrier shift under modulation. For this reason both discriminators are approximately 2 mc wide.

Section VII

SUMMARY

The use of solid-state circuitry has resulted in an advanced wide-band direct FM system which is well-suited for broadcast of mono, stereo, or SCA programs. The system consists of a stereo generator and a wide-band direct FM exciter. The principal advantages of this equipment over other types are as follows:

(1) High reliability due to extensive use of solid-state circuitry.

(2) Low distortion and high signal-to-noise ratio, both exceeding FCC specifications.

(3) Channel separation in excess of FCC requirements without readjustment after original factory setting.

(4) Channel separation not dependent on matching of circuitry in separate signal paths.

UTILIZING A 950 MCS. STL FOR REMOTE CONTROL OF AM OR FM TRANSMITTERS

by

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In recent years the remote control of AM and FM transmitters has become a desirable form of operation from both the technical and economical aspects of broadcasting. The classical approach of using wire lines as the connecting link between the controlling studio and the remote transmitter has not been completely satisfactory. Consider for a moment the number of choice mountain tops that would make excellent FM sites except for the fact that the construction costs and monthly rental rates for wire program and control circuits are extremely high. While standing at the base of such a site and gazing toward the top, one can well appreciate the costs involved in running and maintaining the lines. In other instances, high surface winds, fire, falling objects, and even hunters have been the cause of interrupted control lines. All of these mishaps render the transmitter inoperative due to the fail-safe provisions of the remote control equipment. Thus, there is a need for a control system which eliminates the necessity for telephone lines.

Utilizing a studio-transmitter link operating in the 942 mcs to 952 mcs band as provided by Subpart E, Part IV of the Rules and Regulations is an effective method of accomplishing the remote operation of a broadcast transmitter. In any such system the STL fulfills two important tasks: 1) the conveyance of main channel programming from the studio to the transmitter, and 2) the relay of the necessary control tones for the remote control of the transmitter. Generally speaking, the methods of relaying program and control signals to the remote site are common to both AM and FM installations. The primary difference, however, between the remote operation of these two types of broadcast stations is in the technique of returning the metering information to the controlling point. It is the purpose of this paper to present some of the considerations involved in using an STL to completely control a remote transmitter by means of radio circuits.

The basic elements of a radio remote control system can best be pictured by first considering a monaural FM transmitter with one SCA multiplex subcarrier. Let us assume that we want a control system which is accurate, reliable, secure, conservative of spectrum, and economical to operate. Figure 1 is a block diagram of such a system. The items on the left are located in the controlling studio, and those on the right are at the transmitter site. Suitable low level supersonic control signals are simplexed with the program for relay to the transmitter by a 950 mcs STL. The main design requirements involved in this operation are to insure the frequency stability of the control oscillator by careful component selection and, if required, regulated voltage and to provide sufficient isolation of the program from the control tone spectrum. A sharp cut-off 15kcs low pass filter will eliminate spurious program content from falling into the 17kcs to 20kcs control spectrum. Complete control can be performed with only three tones; raise, lower, and stepper. Additional control channels can, of course, be added to provide a system with greater flexibility. Since a feedback loop is not provided for the stepper switch in this system, means must be provided to synchronize the studio control position with the actual position of the controlling stepper switch at the transmitter. This can easily be done by using pulse duration techniques with the stepper control oscillator. Short pulses, for example, can be made to advance the stepper to the next position, and a long pulse can be employed to home the stepper.

For our FM example, the metering information associated with the remote transmitter is returned to the controlling studio as an SCA multiplex subcarrier in accordance with Sec. 3.293(a1). Here we come face to face with the essential difference between controlling FM and AM transmitters by radio. Because of the bandwidths associated with FM, the metering data can be returned to the studio using any suitable subcarrier frequency in the SCA spectrum. Standard broadcast transmitters unfortunately do not share this ability, and hence this is one reason why radio control systems have not been applied to AM stations. In Figure 1 we notice that the station monitor is located at the studio with a suitable R.F. amplifier to provide the R.F. drive necessary for the types of monitors in use today.

The metering subcarrier is recovered prior to the de-emphasis network in the monitor receiver and is applied to the Studio Control Unit where it is demodulated to recover the metering information. If desired, a stepping switch in the Studio Unit can be operated in synchronism with the remote stepper to route the telemetered information to individual meters for easy read-out. Using motor driven cams, such a remote control system can, of course, be readily adapted for automatic logging.

Another essential element in remote operation is the need for communication between the studio and transmitter. In our example, this is done over one of the I or J remote pick-up channels (26 mcs band) which can be used for such purposes when employing an STL. The 27 mcs citizens band is also available but is less desirable because of the interference problem. Multiplexing both the STL and FM main carrier is another method, but this is usually too expensive although quite secure.

Figure 2 shows the control system in greater detail. A switching control channel is shown in addition to the three transmitter control circuits. This channel as shown is not associated with the telemetering operation, nor is it part of the stepper switch sequence. Thus, it serves as an independent control channel that can be actuated at any time. The use of this circuit is limited to the imagination of the station engineer. Selectivities in the order of several hundred cycles are required for the control tone detectors. This will permit some system drift to be tolerated, but it will offer sufficient rejection to an adjacent control signal separated by as little as 1000 cps. Again, component selection is important in the control filters.

As mentioned previously, it is necessary that some protection be provided in the control system to eliminate accidental control operation by program harmonics or spurious content. The low pass filter shown in Figure 3 is quite satisfactory for this purpose. The control tones can be placed in or above the shaded area.

The selection of the SCA metering subcarrier is a function of the type of operation planned. If monaural programming and SCA operations are planned, it is desirable to locate the metering subcarrier in the extreme low end of the 20kcs to 75kcs SCA band since the bandwidth required by the metering channel is very small. This will allow the most desirable portion of the SCA band to be used for program services. With FM stereo, however, the use of a low frequency subcarrier is precluded as the SCA spectrum is limited to frequencies between 53kcs and 75kcs. Also, the allowable SCA deviation limitation of 10% makes the use of two SCA subcarriers highly unlikely. A system is needed in which the metering and SCA program share a common subcarrier. Because of this relatively low amount of main carrier deviation allotted to the SCA subcarrier, any system for sharing the SCA subcarrier should not greatly reduce the effectiveness of the program matter. One solution is to employ low level, low frequency signals which will not create undesirable effects on the program. High frequency signals are likely to create out-of-band radiation. Thus, the output of a voltage controlled oscillator operating in the spectrum below 40 cps can be mixed with the background music service without noticeable interference, especially if the 67kcs subcarrier is not deviated in excess of 10% by these metering signals. The degradation to the SCA program is then similar to the amount of degradation suffered by the monaural listener of an FM stereo signal. This statement, of course, refers to the actual subcarrier swing and not to the loss of carrier injection percentage.

The detection of low frequency signals in the presence of programming is more difficult to achieve than the demodulation of a normal subcarrier signal since an FM/FM/FM process is involved. Figure 4 is a plot showing the transfer characteristic of an amplifier containing three twin-T networks and six RC filter sections. An amplifier having this response is capable of completely recovering the metering information in the presence of a 100% modulating signal as low as 60 cps. Such conditions exist in practice only under sine wave testing and not during normal intervals of meter reading.

Figure 5 shows the transmitter control equipment at a typical

STL remote control installation. The equipment in the left-hand rack utilizes low frequency metering signals on a 67kcs SCA subcarrier. One interesting feature of this installation deals with the use of the SCA subcarrier. The output of a 160 mcs remote pick-up receiver is used to modulate the 67kcs subcarrier, thus making it possible for the station to originate on the spot remote broadcasts without arranging for wire circuits. The remote broadcast is, of course, relayed to the studio via the 67kcs channel, detected, and applied to the main channel program input for rebroadcast or, in some cases, to the companion AM station. Figure 6 shows the Studio Control Unit and associated subcarrier monitors. It is necessary to multiplex the STL with another subcarrier if modulation from the studio is to be applied to the 67kcs subcarrier. This is necessary since the 67kcs subcarrier generator must be placed at the transmitter site to meet the metering requirement.

Fail-safe can be accomplished by sensing the presence of the STL carrier. This provides an easy way, in fact, to control primary power to the transmitter. Thus, when the STL is turned on, filament power is applied to the main transmitter. In cases where the station is operated full time, it might be more desirable to place the fail-safe in series with the door interlocks to avoid transmitter recycling time in the event of short interruptions of power.

Turning now to radio remote control of AM transmitters, it is apparent from the foregoing discussion that the major difficulty to be encountered deals with the method of returning the metering information to the controlling studio. The methods of delivering the program and control signals to the transmitter site are the same as with FM stations. It should be pointed out that the quality of the STL program transmission will be far superior to that offered by Class A lines. The present Rules and Regulations governing standard broadcast stations do not provide for either A2 or A9 emission for metering purposes. As mentioned earlier, a channel in the I or J remote pick-up bands can be used for communication between the studio and transmitter when an STL is employed. The Commission, in this connection, has considered that unmanned telemetry equipment for relaying the metering data by 26 mcs is the same as if a man were stationed at the remote transmitter site to read back meter information. Thus, if the Commission maintains this policy, an AM station can utilize the I or J band as the return leg in a radio remote control system. Here then, the equipment needs are essentially the same as with FM transmitters except the metering signals must be compatible with the bandwidth requirements of the I or J bands. A simple FM/FM telemetry system will accurately serve as the metering link. The restrictions imposed in the Rules and Regulations relating to the remote operation of such remote pick-up stations must be complied with.

From an engineering point of view, however, there are several disadvantages to the use of the I and J bands. These are; 1) non-exclusive use of the frequency, 2) metering information is junior to program transmissions and the cues relating thereto, and 3) the propagation characteristics of 26 mcs can result in interference received from distant points. All or any one of these reasons can have detrimental effects on the accuracy and reliability of the metering system.

One method which we believe to have considerable merit is to utilize intermittent low frequency signals on the carrier of the AM transmitter. The method would be quite similar to that used in the control system described earlier for FM stereo operation. Such signals could be of short duration - just sufficient for meter readings - and then be turned off by a control circuit. Restricting the signals to the spectrum below 40 cps and the amplitude to less than 10% modulation would prevent any noticeable degradation to the quality of the main program. Most AM transmitters will faithfully reproduce low frequencies at this reduced level of modulation. The use of low frequency metering signals will remove the disadvantages resulting from the use of a 26 mcs circuit and would most certainly result in conservation of an already crowded spectrum. Such a system also offers security since extraneous R.F. interference will not be present. One major advantage to STL control of AM and FM transmitters is that the station can exercise complete control over the entire broadcast operation and consequently does not depend upon an independent party to repair control circuits that have failed. A Petition for Rule Making has recently been submitted by Moseley Associates, Inc. requesting the necessary revisions to the Rules and Regulations to permit low frequency signals for metering purposes.

Good maintenance is the key to uninterrupted operation in any remote control installation. There is a good deal of meaning to this simple statement. The saying, "For want of a nail, the kingdom was lost," can be applied to remote operation whether radio or wire lines are involved. Certainly at mountain top sites it is wise to maintain a regid and well enforced inspection schedule. Adequate spare parts are a must.

It should be noted that any system relying on the main carrier for return of the metering information does not provide the operator with any metering data until the plate circuit is energized. Some operators have a feeling of being in the dark until the carrier comes on. This feeling, of course, can be overcome when confidence is gained through usage of the system. Another matter in STL control relates to the operational simplicity of the system. The system should be straightforward with as much redundancy in the circuit design as possible. Reducing the number of control and metering functions to a minimum is desired. Over-metering, so to speak, is dangerous and should be avoided.

In discussing the STL control of FM stereo stations, consideration was given only to the control aspects. Equally important is the matter of sending both stereo channels to the transmitter. As was pointed out in a paper presented at the 1961 NAB Convention, relaying the composite stereo signal over an STL or telephone line is not practical because the lack of uniform amplitude response and phase linearity in the transmission system causes loss of stereo separation, particularly at both ends of the audio spectrum. However, if the stereo channels have not been matrixed, some delay and amplitude variation can be tolerated. However, the need for a 63db to 65db S/N ratio is very important in each channel since these will be added together to produce the sum information for the main channel modulation. This combined signal will then modulate the main exciter which will contribute to the over-all system S/N ratio.

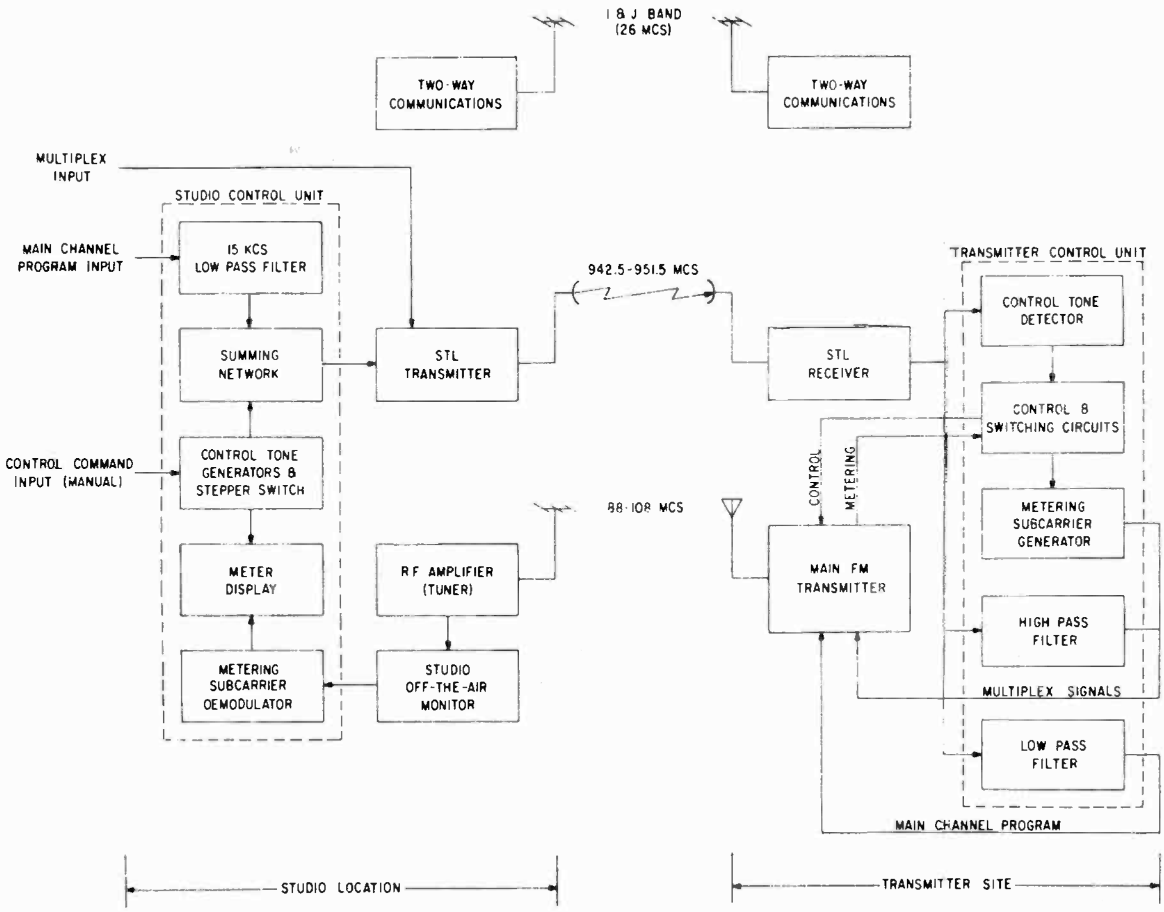
Tests in our laboratory have shown that it is extremely difficult to multiplex an STL to obtain a second channel with the required S/N ratio and amplitude response necessary for stereo transmission while confining all emissions within the allowable limits. An examination of the emission formula for F9 service in this band, 2M+2D= 500kcs, will quickly show that the use of subcarriers capable of handling the desired signal bandwidths will necessarily reduce the S/N ratio of the main channel and will also provide a poor modulation index for the subcarrier. The need, however, to have two high quality audio channels is obvious if the remote transmitter is to broadcast stereo. The assignment of two STL channels is not considered practical by the Commission as this could create allocation problems.

To solve this apparent dilemma we have proposed a system to the Commission using two STLs operating within the bandwidth of a single channel assignment. Figure 7 shows the basic proposal. In essence, two carriers are offset from the assigned center frequency by ±110kcs. With the deviation of each STL limited to ±75kcs, a guard band of 70 kcs remains between the upper and lower sidebands of the lower and upper STLs respectively, and the emission at both extremes of the channel is 15kcs within the maximum allowable frequency swing. Other than providing for the offset carriers and reduced frequency deviation, the only other amendment needed to the Rules is that the center frequency tolerance of the STL be ±0.001% rather than ±0.005%. This does not present a problem in present day equipment.

Figure 8 is a spectrum study of this operation. In the upper photo, one STL is modulated with a 5kcs signal and the other a 10kcs signal, each at 75kcs deviation. The 10kcs modulation has been replaced with a 75kcs signal in the lower photo to serve as a calibration.

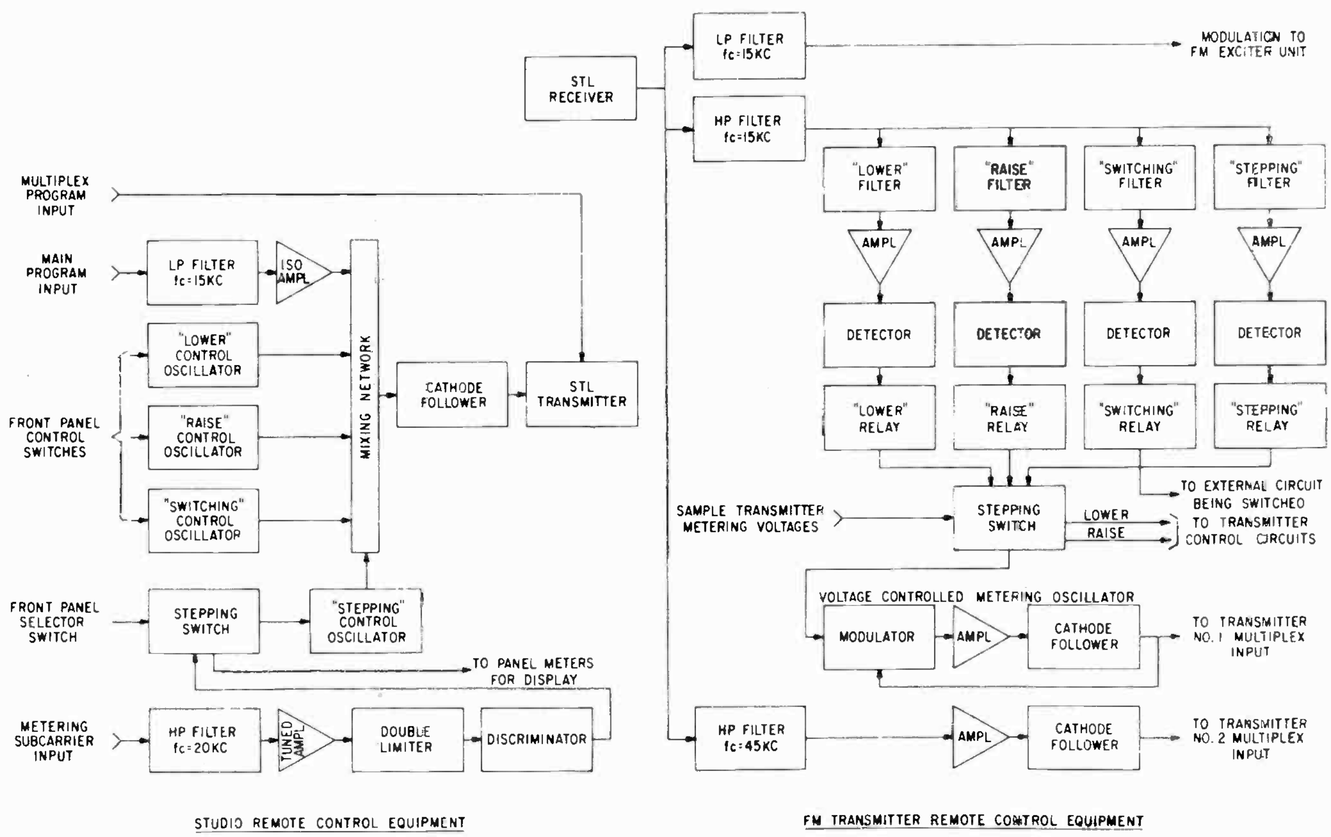
Thus, a dual STL system as outlined here will deliver two high quality audio signals to a remote FM transmitter along with the required control signals and multiplex channel for SCA programming. All radiation is held within the allotted channel assignment.

In conclusion, STL remote control operation can be effectively employed in both FM and AM stations. The reasons for the use of a control system may vary with each installation; however, in all cases excellent program quality, low operating costs, and reliability are realized by a Radio Remote Control System.



I & J BAND
(26 MCS)
TWO-WAY COMMUNICATIONS
TWO-WAY COMMUNICATIONS
MULTIPLEX INPUT
STUDIO CONTROL UNIT
MAIN CHANNEL PROGRAM INPUT
15 KCS LOW PASS FILTER
SUMMING NETWORK
STL TRANSMITTER
942.5-951.5 MCS
TRANSMITTER CONTROL UNIT
CONTROL TONE DETECTOR
STL RECEIVER
CONTROL & SWITCHING CIRCUITS
CONTROL COMMAND INPUT (MANUAL)
CONTROL TONE GENERATORS & STEPPER SWITCH
CONTROL
METERING
88-108 MCS
METERING SUBCARRIER GENERATOR
METER DISPLAY
RF AMPLIFIER (TUNER)
MAIN FM TRANSMITTER
HIGH PASS FILTER
METERING SUBCARRIER DEMODULATOR
STUDIO OFF-THE-AIR MONITOR
MULTIPLEX SIGNALS
LOW PASS FILTER
MAIN CHANNEL PROGRAM
STUDIO LOCATION
TRANSMITTER SITE

Fig. 1



LP FILTER fc=15KC
MODULATION TO FM EXCITER UNIT
STL RECEIVER
HP FILTER fc=15KC
"LOWER" FILTER
"RAISE" FILTER
"SWITCHING" FILTER
"STEPPING" FILTER
MULTIPLEX PROGRAM INPUT
AMPL
AMPL
AMPL
AMPL
MAIN PROGRAM INPUT
LP FILTER fc=15KC
ISO AMPL
DETECTOR
DETECTOR
DETECTOR
DETECTOR
"LOWER" CONTROL OSCILLATOR
MIXING NETWORK
CATHODE FOLLOWER
STL TRANSMITTER
FRONT PANEL CONTROL SWITCHES
"RAISE" CONTROL OSCILLATOR
"LOWER" RELAY
"RAISE" RELAY
"SWITCHING" RELAY
"STEPPING" RELAY
TO EXTERNAL CIRCUIT BEING SWITCHED
"SWITCHING" CONTROL OSCILLATOR
SAMPLE TRANSMITTER METERING VOLTAGES
STEPPING SWITCH
LOWER
RAISE
TO TRANSMITTER CONTROL CIRCUITS
FRONT PANEL SELECTOR SWITCH
STEPPING SWITCH
"STEPPING" CONTROL OSCILLATOR
VOLTAGE CONTROLLED METERING OSCILLATOR
MODULATOR
AMPL
CATHODE FOLLOWER
TO TRANSMITTER NO. 1 MULTIPLEX INPUT
TO PANEL METERS FOR DISPLAY
METERING SUBCARRIER INPUT
HP FILTER fc=20KC
TUNED AMPL
DOUBLE LIMITER
DISCRIMINATOR
HP FILTER fc=45KC
AMPL
CATHODE FOLLOWER
TO TRANSMITTER NO. 2 MULTIPLEX INPUT
STUDIO REMOTE CONTROL EQUIPMENT
FM TRANSMITTER REMOTE CONTROL EQUIPMENT

Fig. 2

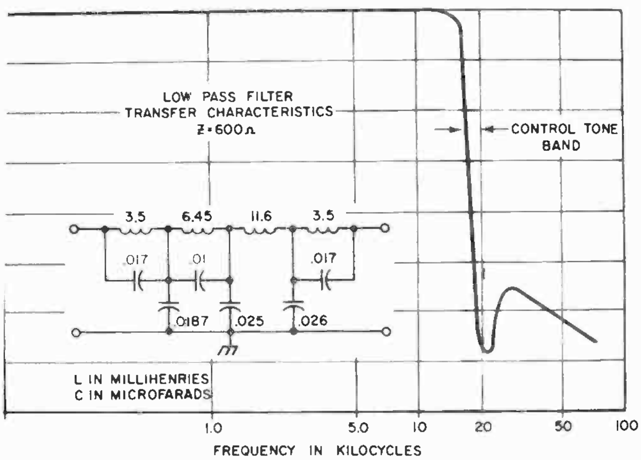


Fig. 3

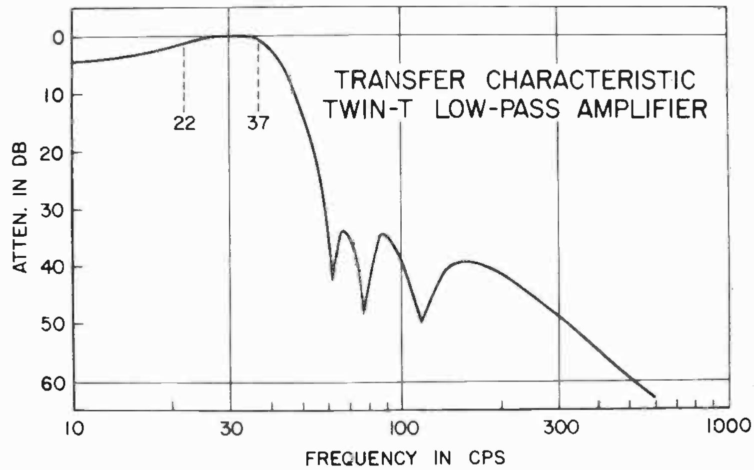


Fig. 4

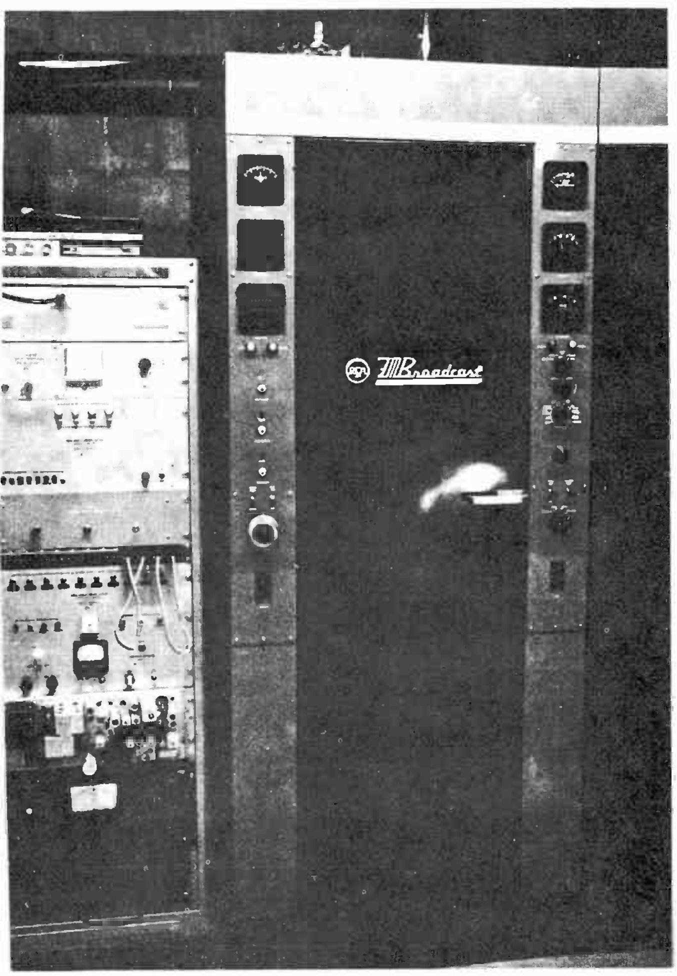


Fig. 5

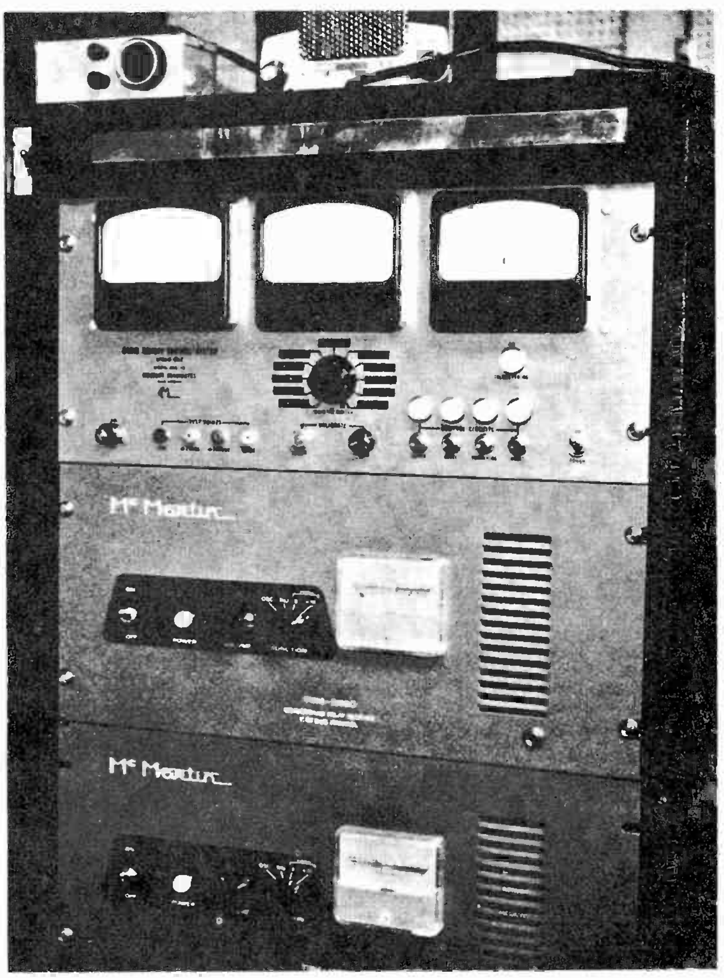


Fig. 6

1. STL CARRIERS OFF-SET ±110KC
2. 100% MODULATION EQUALS ±75KC
3. FREQUENCY TOLERANCE ±0.001%

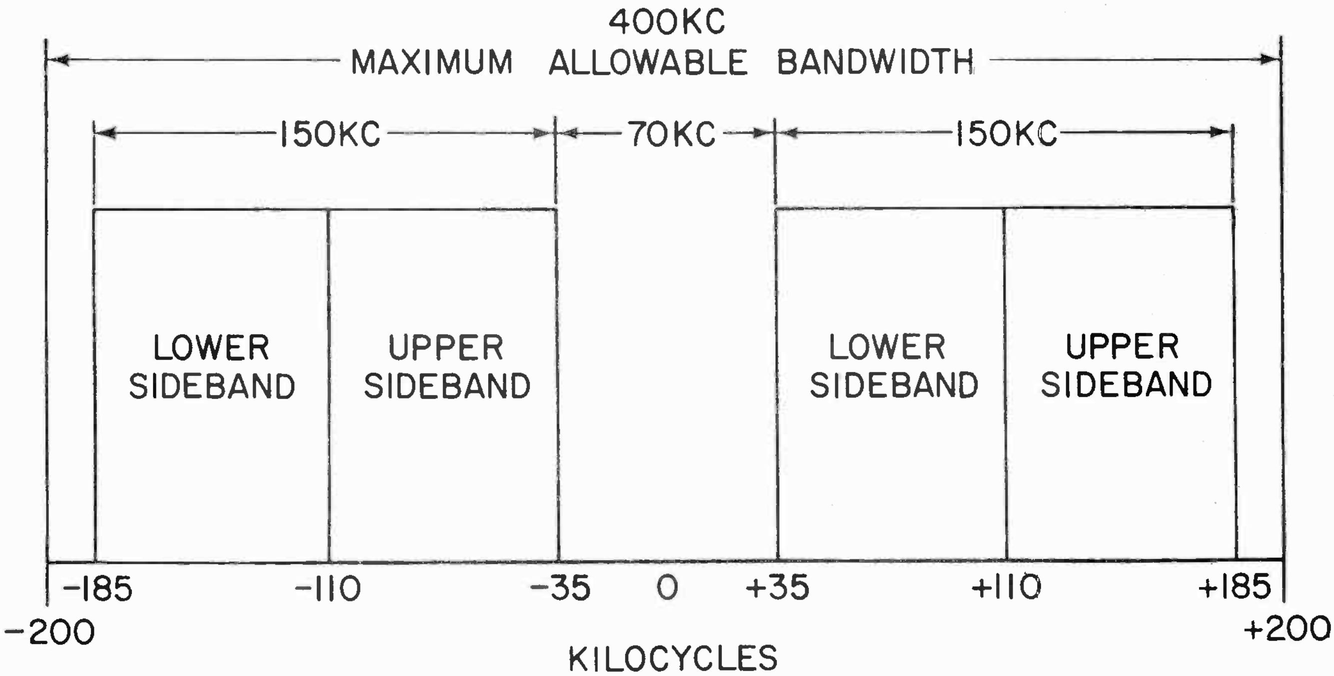


Fig. 7

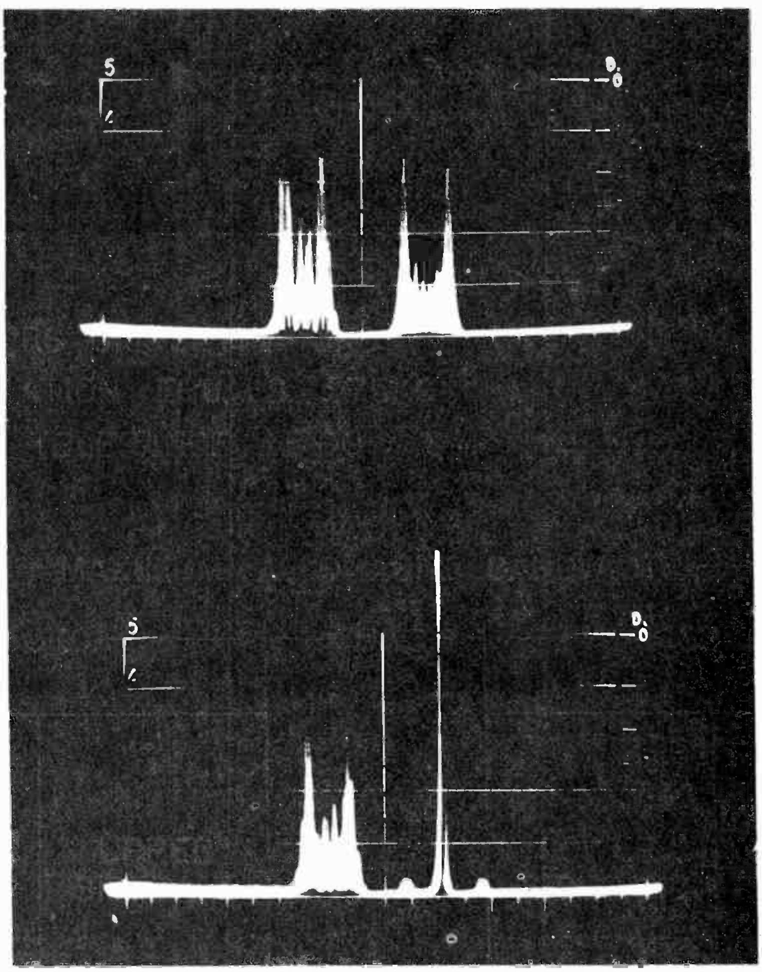


Fig. 8

CARTRITAPE PROGRAMMING TECHNIQUES

By - Ralph L. Haberstock, Senior Audio Engineer

Gates Radio Company, Quincy, Illinois.

Cartridge tape equipment, which has been available to the broadcast industry for some time now, has performed a very useful function. It has greatly relieved the frantic jam in the control room during station breaks and other peak traffic periods. Previously, the control room operator had to thread and cue up tapes, search for the correct segment and cue up transcriptions, anticipate the right instant to start the next machine, switch and fade the correct source in the console at exactly the time the last segment ended. This superhuman performance was demanded during the critical portion of the broadcast day when the station earned the bulk of its revenue and could not afford errors.

The improvement of this operation, by the introduction of cartridge tape machines, was so great that their lack of professional quality was initially tolerated. Advances in the state of the art, as well as new innovations, now allow cartridge tape machines to enjoy comparable quality and features formerly found only in professional reel-to-reel tape machines.

This paper will outline some of the differences and features of the new system we have developed. The older method of using staggered heads for Program and Cue has been abandoned in favor of the stacked stereo head arrangement, which is now a standard in the recording industry. This allows separate Recording and Playback heads to be used with the small cartridge containing only two head openings. The other advantages include: head switching, with the resultant noise problem, is no longer required in Record/Playback units. Simultaneous recording and monitoring is permitted, which was impossible with the staggered heads, as shown in Figure 1. Azimuth adjustment, frequency response measurements and distortion measurements are greatly facilitated so many stations will regularly measure them for the first time.

The cross-talk remains lower than noise with the stacked stereo head arrangement, as shown in Figure 2. The noise is reduced to -55 db or more, below the 3% total harmonic distortion point, even on Record/Playback units. Therefore, the two track stacked stereo head is used in the monophonic cartridge tape machine, with the upper track for the Program content and the lower track for the cue signals.

The recent FCC approval of FM stereo has created a demand for stereophonic cartridge tape equipment. Perhaps it has created a greater demand for new monophonic units that can be easily and economically converted to a stereo when, and if, desired. The design of our new cartridge tape system followed this precept. We were gratified to find that little, if any, compromise was required to accomplish this goal. Of course, there were many additional design goals that will be covered later in this presentation.

The Playback unit is constructed with all the cue tone amplifiers and program amplifiers on plug-in chassis. They are built on glass base printed chassis assemblies with gold plated connectors for extreme reliability. The receptacles for a full complement of amplifiers of both types are installed and wired in the basic unit, thus, the conversion is very simple.

A three track head is required when changing a Playback unit from monophonic to stereophonic operation, as shown in Figure 3. The track locations and dimensions shown apply to the individual recording head. The playback heads are .032" wide, .008" less than the recording head, to allow more tolerance in vertical alignment and further reduce the possibility of cross-talk. The track widths of the head shown in Figure 3 are the same as the standard 1/4 track head dimensions now in use by the recording industry. Spacing three of these tracks in this manner, assures maximum land or guard area and cross-talk substantially lower than noise.

Another major improvement of our new equipment over most old cartridge tape machines is the reduction in size, allowing a much more compact system. They require only 5-1/4" of panel space and are only 12" wide in the desk mount version. Mounting adaptors permit their use in a 15" custom cabinet, as well as adaptors for standard 19" rack mounting. To further save valuable station space, the Recording Amplifier attaches to the side of one of the Playback units to facilitate the mounting of both units in a single 5-1/4" X 19" rack panel space or 5-1/4" X 17" desk mounting. This provides a compact Record/Playback unit that may be used for playback only, when it is not in use for recording.

Older cartridge tape machines used a single cue tone to stop the cartridge when it had run back to the starting point. This system performed very well but within the following limits:

1. If more than one cartridge is to be played during a station break, the second and subsequent ones must be started manually. It is not feasible to rely upon the single cue tone to actuate the next cartridge machine since the recorded message seldom is timed to completely fill the cartridge.

2. The attempt to overcome this timing problem by recording multiple non-package spots on a single cartridge is seldom satisfactory. Almost all flexibility is lost because of the inability to fully intermix them.

3. A single cue tone system is not capable of switching auxiliary devices during a single message, such as changing slides on a TV commercial. Thus, it is essentially limited in operation to a manual control.

In summary, the single tone system of cueing has a very definite place in certain broadcasting applications. However, this system is not applicable in many, if any, automatic programming applications.

The next logical refinement of cartridge tape systems would be the addition of a second cue tone. In the two tone system, a tone is applied at the beginning of the message in the same manner as the single tone system. Our system, with its plug-in tone channels permits a choice of the second tone. It may be either a 200 cycle tone for "random" switching or a 5 KC tone for "end of message" switching.

This second cue tone will cause a pair of relay contacts to momentarily close, to automatically actuate the next program source whether it is another tape machine, projector, turntable or some other preset program. This second tone can also be chosen to actuate any number of auxiliary program devices such as slides. In either case the second cue tone does not stop the cartridge. It continues to run until it reaches the first cue tone, where it stops - ready to use again.

The following advantages are obtained with our two tone system:

1. The first cue tone is the standard 1 KC tone used in nearly all older systems and allows the two tone unit to be incorporated in a mixed system.

2. Packaged spots from a single sponsor and rotating intro's can still be recorded "end to end" for automatic rotation each time it is played.

3. It is possible to program an entire station break automatically, with the use of several multiple tone machines, by starting just the first machine in the sequence.

4. Placing only one message on a cartridge allows maximum flexibility in intermixing. This flexibility is further enhanced by the use of a second cue tone.

5. Part time automation is feasible with three or more Playback units and a low cost Segue unit. The Segue unit is designed to fit on the extension side panel of one of the regular Playback units, thus, further conserving rack space.

Figure 4 shows the operation of an automatic Segue system. The master Playback unit is interconnected with three other "slave" Playback units through the Segue unit. However, three, four, six or twelve Playback units may be used in this system.

The cartridge for the master unit contains all spots, themes, etc. These are recorded in the same sequence in which they are to be aired. A recorded library of cartridges, perhaps the top 40, is prepared with one selection per cartridge. The Segue unit then directs the "start" cue from the Master unit to the next Slave playback unit. This is accomplished by the stepping of the Segue unit, each time the Master starts. This results in automatically alternating between the spots and music, because each time the end of one of the music selections is reached, the "start" cue from this machine actuates the Master machine. Another spot is played and the Master starts the next Slave, etc.

The operation must follow the cue sheet in interchanging the cartridges that have been played with those coming up to achieve flawless short term automation. Once a library has been started it is necessary to make only occasional additions or changes to keep it current with the top 40 tunes. The status lights of the Playback machines will keep the operator fully informed of the unit in use and when a used cartridge is cued back up ready to be interchanged. Using cartridges without excessive time capability, over that required for the selection, will help keep the system simple and easily operated.

In summary, the two tone system is more versatile than the one tone system, in that it lends itself to automatic or semi-automatic operation. This automatic operation can be either "end of message" cue tone switching or "random" cue tone switching. Most of the discussion above was on the "end of message" system. The "random" system is used for TV slides, permitting any number of impulses to be placed at any point desired during a single message. This allows the TV spot to be polished to a flawless operation so that the pressure of manual performance is eliminated, with its great chance of errors. The spot may be reused with identical performance as many times as desired. Thus, the two tone cartridge tape systems fills most of the programming needs of a modern station, with the exception of multiple spots with random slide switching.

By the simple addition of the third cue tone, both "end of message" and "random" switching are obtained for the ultimate in cartridge tape machines.

With a full complement of cue tones the system provides truly automatic operation. The one time hectic TV station break can now become a smooth programmed time segment. A typical break of this type can use as many as four cartridges and display as many as thirty slides. Previously, with the two tone system, slide changing was possible, however, there was no provision for "end of message" switching.

This necessitated the manual starting of each cartridge in sequence in order to complete the break. With our three tone system, slides are displayed as called for by the "random" cue tone, and the "end of message" switching starts the next machine. The following advantages are obtained with our three tone system -

1. This system provides the standard 1 KC stop tone recorded at the beginning of the message - just as used on nearly all of the older systems.

2. "End of message" switching is supplied automatically on each cartridge by the second cue tone, which is 5 KC.

3. The third tone is random and may be recorded on the tape as many times and wherever necessary for programming effect. This "random" cue tone operates at a frequency of 200 cycles.

For equipment of this type to be truly effective in the broadcast station, extreme reliability is necessary. For this reason, special consideration has been given the cueing circuitry. No attempt has been made to use trick circuits, or unproven techniques, to save parts to produce an economical unit.

Figure 5 shows the relative frequency response of each of the amplifiers. The 200 cycles amplifier utilizes a broad low pass filter for reliable operation. The 1 KC amplifier exhibits a broad band pass to allow reliable cueing, even from existing cartridges in the field. However, it still exhibits adequate rejection to the other cue tone frequencies. The 5 KC amplifier utilizes a high pass filter to obtain the frequency response shown on the graph. This allows compatibility with other manufactured devices using higher frequency trip cue tones. 5 KC is utilized in our system because of its stable recording playback characteristics. The higher frequencies are very sensitive to azimuth variations and result in level changes that could tend to make the system unreliable.

The complete cartridge tape system should be handled in the control room as efficiently as possible. To achieve this, remote starting facilities for each playback unit should be designed into the system. This allows the operator to insert the cartridge into the machine at an opportune moment. Then, at the desired air time, press the remote switch (located near the console) without the chance of the operator accidentally going "off mike". Remote operation of the record functions are also deemed necessary. This allows the announcer to start the recording and to begin speaking immediately after the recording "start" button has been pressed, without waiting for a visible cue signal. This gives the production tight cueing that results in the station displaying the desired live sound to its listening audience. It is advisable to incorporate the automatic audio switching unit into the system along with the remote operation facilities. This device permits four Playback units to be fed automatically into one console input. Therefore, it is not necessary to manually switch the audio each time a unit is started. All too often this facility is omitted in the system planning, and the results are seldom worth the savings in cost. Since a system is not complete without the remote facilities and the automatic switcher, these items are available as part of our new system and should be incorporated into the planning of a new station cartridge system.

An important area often neglected in planning the cartridge system, is cartridge storage. Careful attention must be given to cartridge storage to prevent the cartridges from being hard to find or easily misplaced. The cartridges should be stored near the equipment with which they are to be used. Cartridges should be stored so the operator does not have to stoop abnormally low, or reach excessively, to retrieve a cartridge. If this happens, congestion in the control room will arise. Also, any cartridge storage device should be capable of storing at least 200 cartridges, or even more for the busier stations. Such a device should allow easy access to the cartridge. A sample of the "Lazy Susan" variety is shown in Figure 6. This device will hold 200 cartridges in only 13-1/2" of height. More decks can be stacked if desired, with each deck holding 20 cartridges. A system of cataloging cartridges should be incorporated along with the storage. The cataloging of the cartridges should be easy to see and simple to understand. A simple cataloging system is shown in Figure 7. This system designates rows with letters and levels with numbers as shown in the figure. A glance at his log will show the operator which cartridge is to be played next, and a simple turn of the wrist will easily locate the desired cartridge for insertion into the machine. Notice that the cartridge is marked also, so that it can be replaced in its proper place after use. This is an example of what is required to make cartridge selection easy, accurate and reliable.

If these areas are overlooked in control room planning, the major advantages of the cartridge equipment can be lost and the operation greatly impaired.

A review of these points should consider typical control room requirements. The following points should be incorporated into the system layout:

1. The playback units should be handy to the operator.

2. The cartridge storage facilities should be as close as practical to the playback units, for simple selection and placement in the machine.

3. All of the remote functions should be located near the control console.

4. The automatic switcher should be utilized for automatic audio switching into the console.

Some of the components described in this paper are shown in Figure 8. Shown is a stereo three tone Record/Playback unit, a Playback unit for stereo (three tone), a playback remote unit which can start four playback units and a record remote unit. A system comprised of four Playback units and automatic switcher would only require 22-3/4" of panel space.

Special attention has been given the cartridge slot opening. As can be seen in Figure 8, a sliding door has been employed to cover up the part of the slot which is not being used for larger cartridges. This minimizes dust and dirt in the cabinet, and allows the operator an effective visible target in which to insert his cartridge. Careful attention has also been given the VU meters for stereo. Slide rule VU meters have been incorporated for ease in monitoring and recording stereo program material. These were picked after conducting a careful study among operators of stereo equipment to determine which would be the easiest to use in this application. All playback units are wired for stereo and may be converted at any time by adding the correct head in the playback unit, along with the plug-in amplifiers required.

The switcher is wired for stereo and may be either monaural or converted to stereo by plugging in extra relays.

The professional features usually found only on first rate reel-to-reel machines have been incorporated into the design of this system. Some of these features are -

1. Record input monitoring.

2. Monitoring of the recording off the tape, by use of the separate playback head, while recording.

3. Head switching has been eliminated by utilizing separate record and playback heads.

4. Record head bias can be read on the VU meter.

5. A completely transistorized playback unit for minimum noise and maintenance.

6. In addition, the option to employ one, two or three tones for flexibility, together with monophonic or stereo operation.

7. Synchronous motor.

Cartridge tape systems, as described in this paper, mark the advance from semi-professional devices to well coordinated professional systems required by the discriminating broadcasting industry.

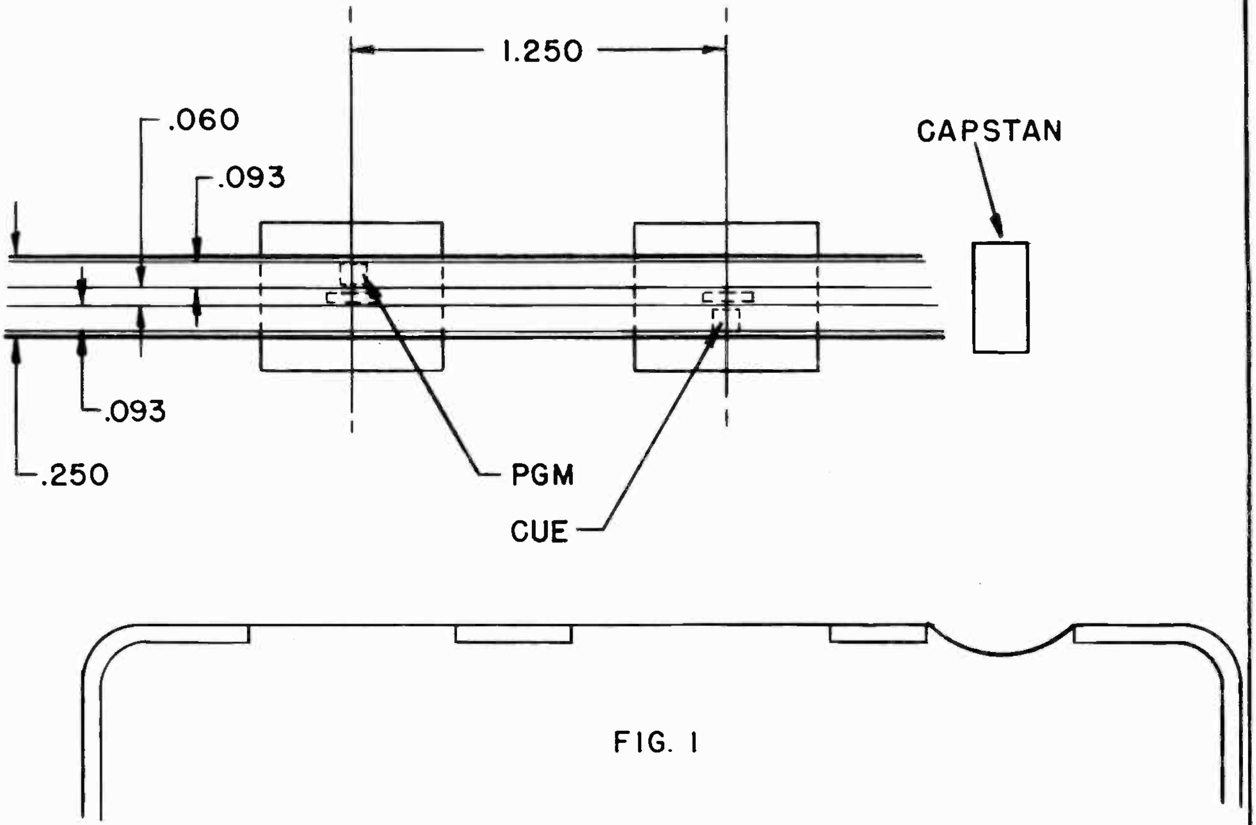

1.250
.060
.093
CAPSTAN
.093
.250
PGM
CUE

FIG. 1

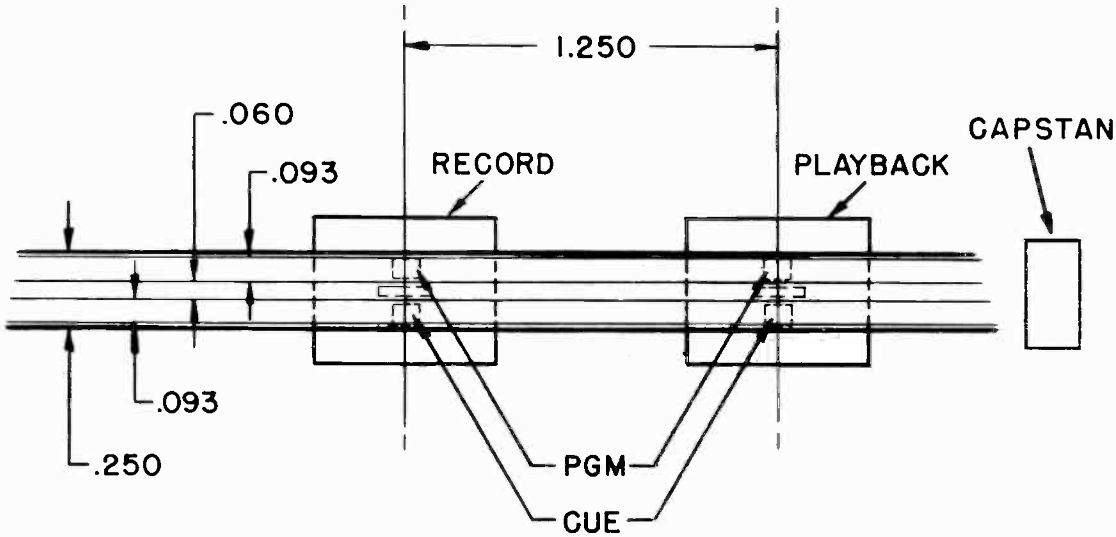

1.250
.060
.093
RECORD
PLAYBACK
CAPSTAN
.093
.250
PGM
CUE

FIG. 2

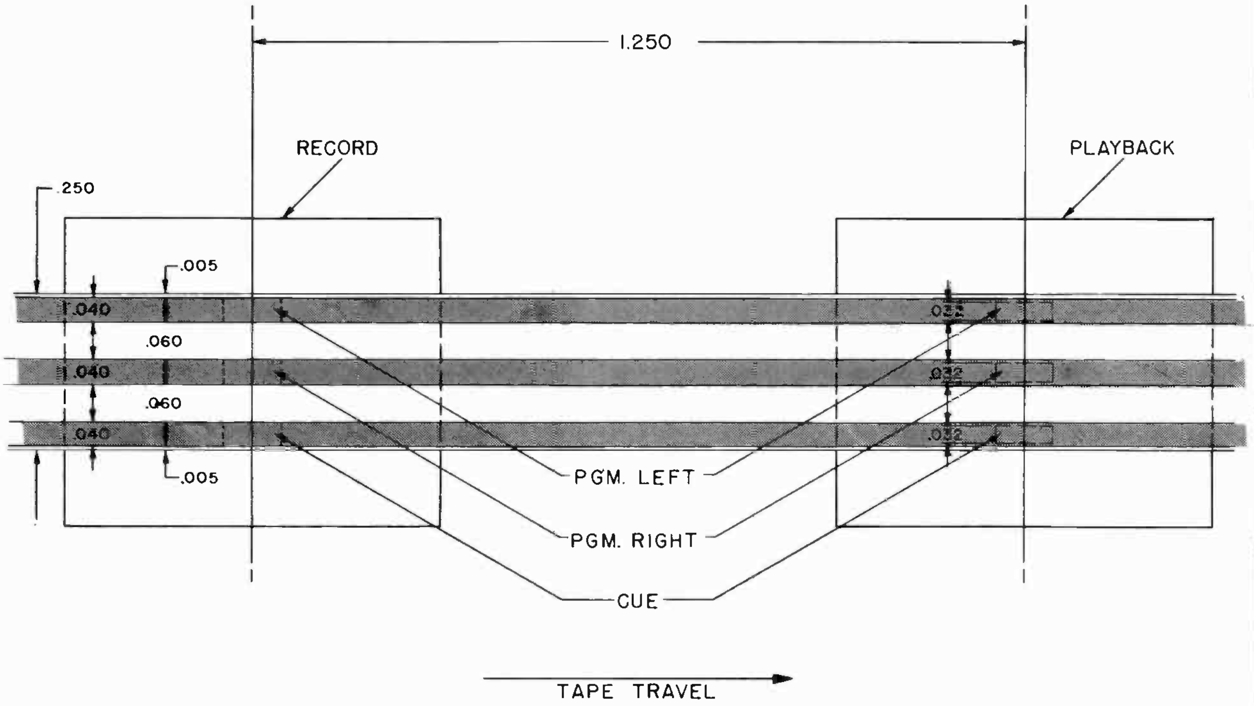

1.250
RECORD
PLAYBACK
.250
.005
.040
.060
.040
.060
.040
.005
.032
.032
.032
PGM. LEFT
PGM. RIGHT
CUE
TAPE TRAVEL

FIG. 3

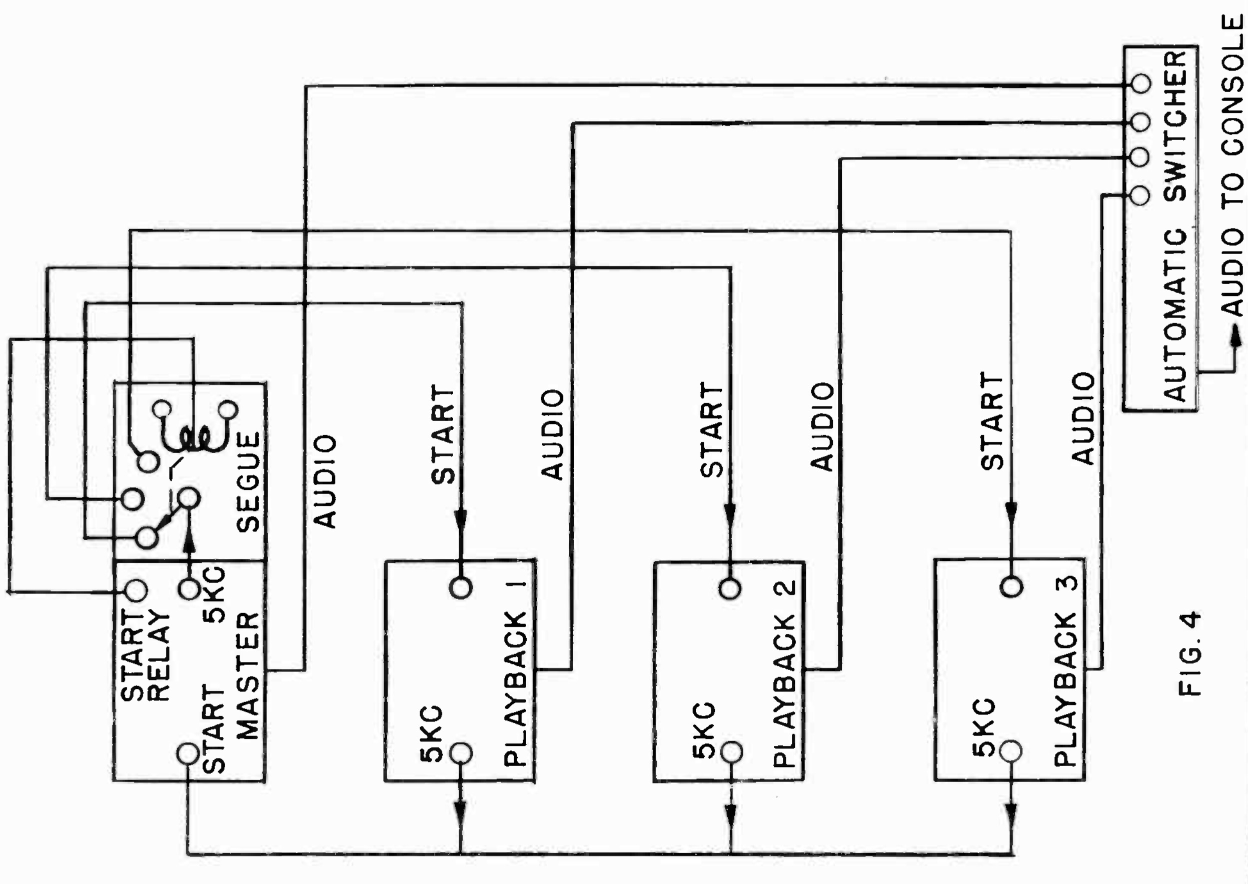

AUTOMATIC SWITCHER
AUDIO TO CONSOLE
SEGUE
START RELAY
5KC
START
MASTER
AUDIO
START
AUDIO
START
AUDIO
START
AUDIO
5KC
PLAYBACK 1
5KC
PLAYBACK 2
5KC
PLAYBACK 3

FIG. 4

CUE AMPLIFIERS FREQUENCY RESPONSE CURVE

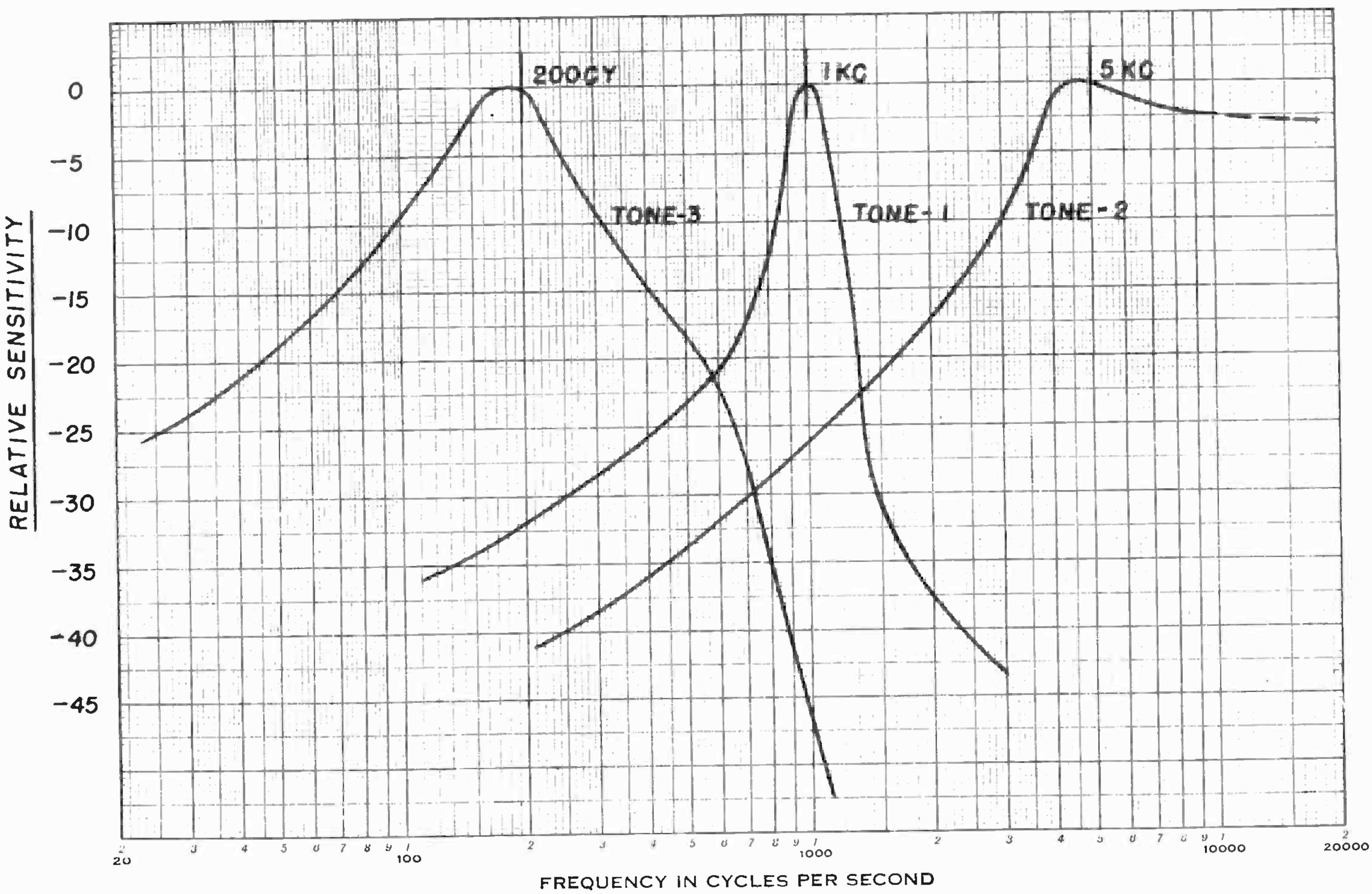


FIG. 5

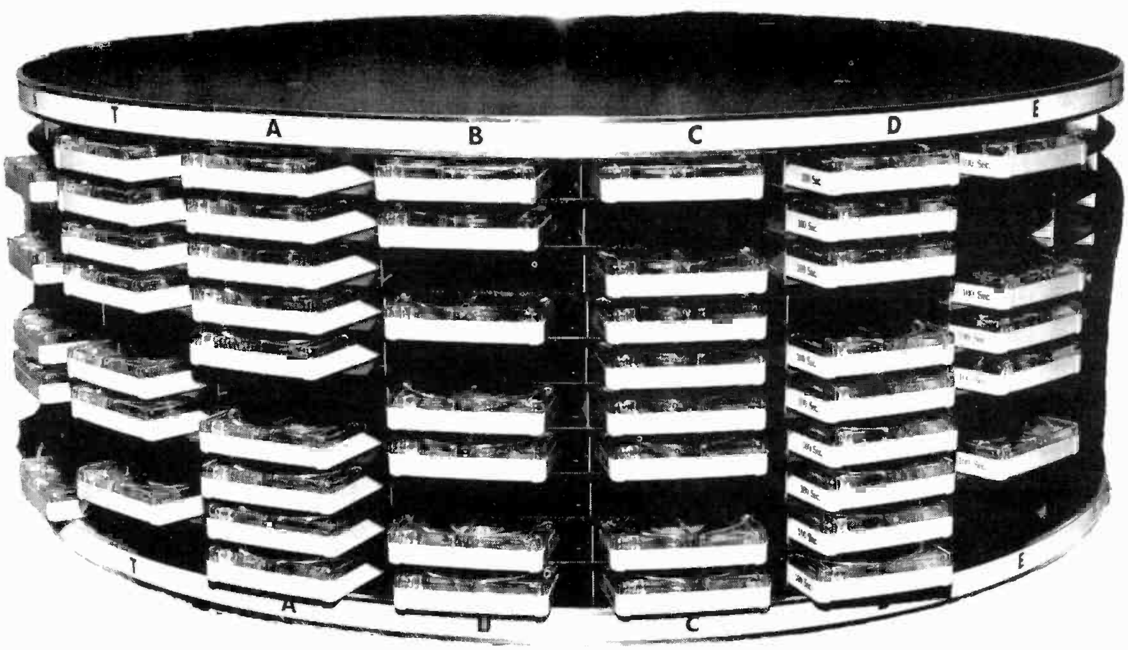


FIG. 6

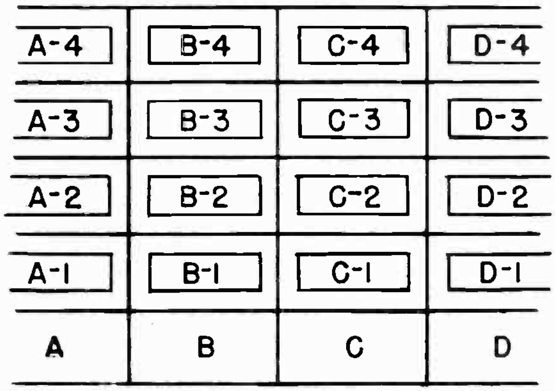

A-4
B-4
C-4
D-4
A-3
B-3
C-3
D-3
A-2
B-2
C-2
D-2
A-1
B-1
C-1
D-1
A
B
C
D

FIG. 7

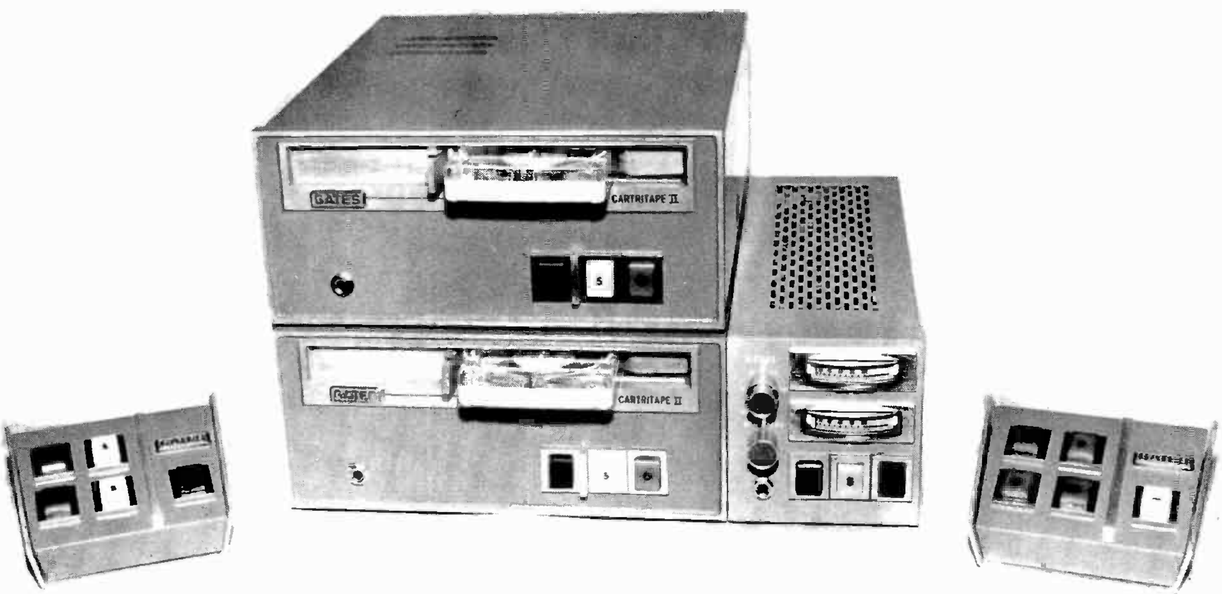

GATES
CARTRITAPE II
CARTRITAPE II

FIG. 8

TECHNICAL ASPECTS OF EMERGENCY BROADCASTING FACILITIES

by James E. Gray, Chief Engineer,
WYDE Radio, Birmingham, Alabama

I wish to express my appreciation to the N. A. B. for being invited to deliver this paper to the 40th convention of this association.

I would like to take a few minutes to emphasize the importance of the radio stations of this nation having emergency broadcasting facilities for use in the event of a nuclear attack. We cannot over-emphasize the importance of this in saving many thousands of lives by warning the public, keeping them informed and thereby holding down panic during the post-attack period. No other medium can reach as many people as radio, which today reaches every nook and cranny of the fifty states of America. The need for radio in perilous times was best illustrated by Dr. Ian Stuart in a tribute to Winston Churchill when during the Battle of Britain, England stood alone fighting Hitler. He said, "But let us not forget that had it not been for radio, Churchill's words could never have reached the ears and inspired the hearts of millions of his countrymen and never have been carried across the Atlantic to reach the ears and inspire the hearts of the American people. Never before in the human story have so many owed so much to one man and the instrument of radio." This is high praise indeed for our medium of radio, which has been taken so much for granted by the public. Radio has served through two World Wars and the Korean conflict, and the public cannot envision that radio might possibly not be here for their guidance and comfort should this country be engaged in an all-out war. But that is the case now, and all stations should make the effort to provide some kind of emergency transmission.

I do not minimize the dangers of radiation fallout, but I do think that the public has had too little education about emergency measures and much more emphasis concerning the dangers of fallout, so that the majority feels that all life upon this earth would be wiped out should a war commence. It is regrettable that this fatalistic attitude exists, but it cannot be corrected until all the media better educates the public to the fact that it is no disgrace to live underground for two weeks or less and that it is a moral duty to save our children's lives. It should be our hope that if such a war occurs, our children will at least have the privilege of trying to make a better world for themselves as our fathers and forefathers did before us.

The first and most important function of all the radio and television stations will be, of course, to give the actual alert of an impending attack and advise the public to dial 640 or 1240 on their AM dial. At this point, all media ceases operation, leaving the Conelrad stations to instruct and inform the population of the action that is to be taken. Those who survive the attack will then have to know what has happened to their city and country, how much damage was done, how many casualties there were, what is happening to the enemy, whether or not we are winning the war, how long we must remain in our shelters and what action must be taken to insure survival. Unlike in the past, people will not be able to run down to the corner and buy a newspaper (they will not be in operation) or to ask a neighbor what he has heard. This time they will have only one contact with the outside world and that contact will be our Conelrad station broadcasting the voices of the city or Civil Defense officials bring instructions and news via radio and at times the calm, confident voice of our President. But if there were no Conelrad and therefore no contact with the outside world, what do you think would run through the minds of the people who would be closed off? Probably each unit of people in each shelter would think that they alone were left and most likely panic would take hold, leading them to take rash action. There have been many tests with people staying 14 days in a shelter under simulated conditions, but these people had contact with the world and could talk with people outside the shelter and listen to the radio for news and music for relaxation. They knew what they would be coming out to. There is no question as to whether or not the public can survive two weeks in a shelter. This people can do easily when their lives depend upon it. But they must be kept informed of what is happening while they are confined, so that they will know exactly what they will be confronted with upon leaving the shelter.

I will not ask for a show of hands as to the number of you present here who are prepared in the way of a fallout shelter, as I do not want to make anyone uncomfortable. And in case you are wondering, let me say that I have a place in my home prepared for radiation fallout and also that I have a conelrad receiver which is tuned at all times to the 24-hour key stations in my city.

Last summer your local State Industrial Advisory Committee mailed to all the Conelrad stations in this country cost estimates for shelters, mobile units, receivers, power units, food and other items to be filled in and mailed to the FCC. I sincerely hope that everyone filled out the form, as this will make each Conelrad station self-sustaining in being able to broadcast in lieu of the phone and power companies. Congress appropriated the funds for this project realizing that the majority of the stations in this country are not financially able to meet the expense of such a project. This program is going rather slowly at the present, as the evaluation of the costs per station has to be finished, but I hope that the funds will be allocated some time this year. This program should not be confused with the fallout program referred to in an artical in the March 5th issue of Broadcasting whereby the government has selected key stations to build and stock fallout shelters.

Now what should your station provide in the way of emergency facilities to broadcast from and how should you go about it? Each station will have to decide which type of facility which would best serve them. My station would not be able to meet the expense of installing a complete broadcast station underground with a retractable antenna and a separate complete transmitter. So, we will use the plan of no bomb blast in our city, or if there is, that if the building and towers are in operating conditions, we will need only facilities to operate from a radiation fallout type shelter. An above-ground type shelter is planned at our transmitter site adjacent to the building with the entrance to the shelter being inside the building. The shelter is to be 64 square feet, which is small but there will be only one man on duty. The control panel in the shelter will be parallel to the transmitter panel along with the final plate voltage and current and antenna and modulation monitor meters -- or, in other words, the transmitter will be remote controlled to the shelter. A patch panel will be installed terminating the telephone, the Civil Defense mobile unit, police receiver, and our regular telephone lines from the studio. As our transmitter building is air conditioned, the operator can leave at various short intervals without worry of radiation dust to check the transmitter and power unit. The responsibility of maintaining the broadcast will be solely upon this one man.

One item we think is necessary is an intercom in the shelter with two stations, one in the transmitter building located near the power unit and the other one on the outside of the shelter with a door buzzer button along side it. We also will have a periscope in the shelter, not only for the morale of the operator, but should he be visited by anyone such as Civil Defense officials, he can identify and converse with them without leaving the shelter.

The table, cots and chairs will all be of the fold-up type in order to provide room for exercising. The power unit will be adjacent to the building, like the shelter, with the entrance from inside the building. This one piece of equipment will require the utmost care and supervision of the operator.

An automatic record changer along with selections of bright, happy music will be wired in for periods of musical interlude should Civil Defense wish it. Our portable tape machine will be moved from the audio rack to the shelter to record anything Civil Defense might want to delay to a later time or to repeat specific instructions that were given earlier.

Our food supply will consist of canned goods and a good supply of C or K rations. We have a bottle-type water cooler at the transmitter with 10 to 15 gallons of drinking water on hand at all times, which will be sufficient for the operator on duty. One thing I would like to stress is to be sure to install enough conduit pipes from the shelter to the transmitter building or to your studios. When our studio underground shelter was installed, I found myself lacking in conduit pipes to the shelter through a misreading of the requirements by the contractor and it was necessary to combine the periscope and the exhaust vent to give me another conduit pipe to finish the circuits to the power unit.

Upon completion of our underground studio fallout shelter we found ourselves still not equipped 100 per cent for the total emergency. How could we properly operate for two weeks from the studio site while the transmitter nine miles away did not have the same facilities as our studio? We decided to hold what we had and, using the experience we had gained from constructing the emergency facilities at the studio, build a fallout shelter at the transmitter which would have all the equipment to be used for broadcast at one location.

Those of you who have remote control facilities have, of course, a different problem. If you have no power or telephone line trouble, you will be able to operate from the remote control site. Should you have power failure or if the power lines are sabotaged, and we must assume that there would be some in our larger cities, it would be necessary to send a man to the transmitter if, for no other purpose than to maintain the power unit, and once he is there he would be required to stay and look after it. Therefore he would need a shelter stocked with food and water. So it is a situation that should be discussed in detail with your Civil Defense officials.

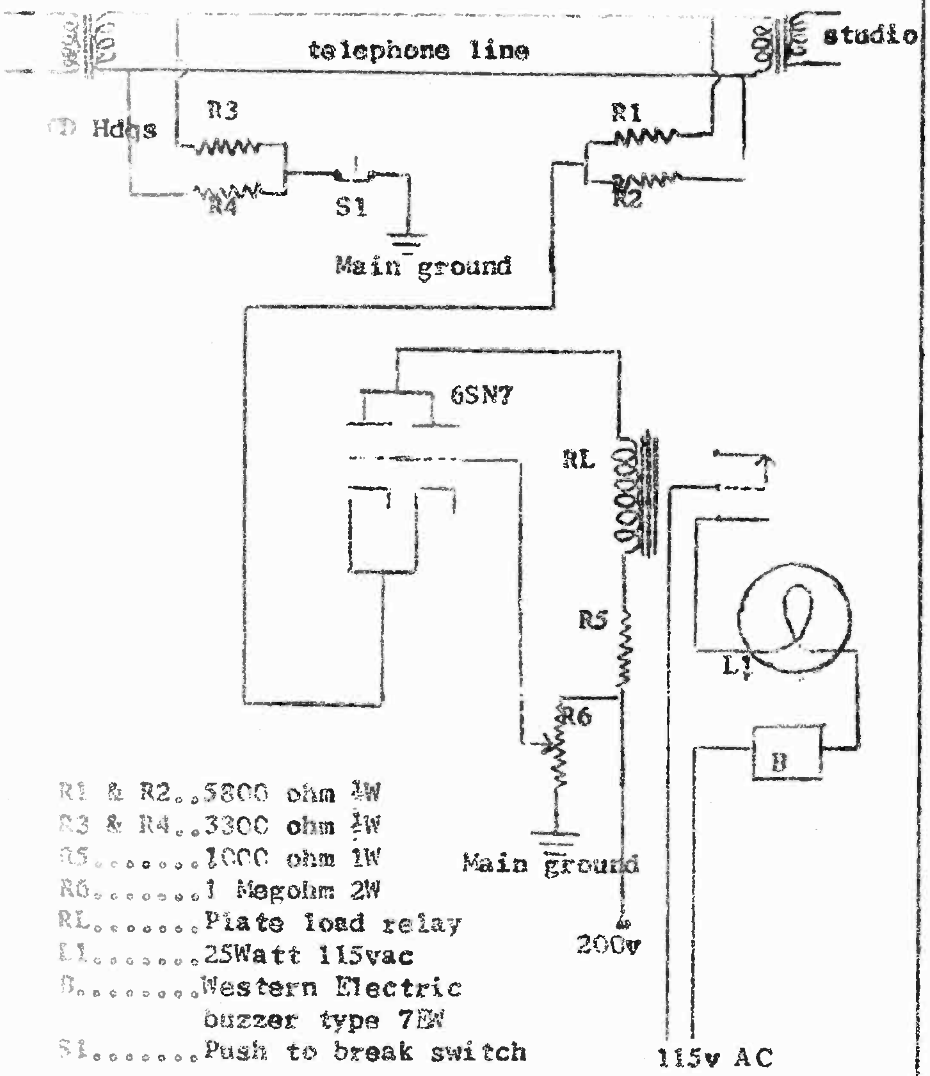
We now have the shelter built and the equipment installed, along with the power unit, all in operating condition. What about the transmitter? Can you or your engineers change rapidly from your normal operating frequency to the Conelrad frequency? I'm not referring to those of you who have standby transmitters tuned to the Conelrad frequency, nor those who are adjacent to the Conelrad frequency requiring only a switching of the crystal and retuning the final stage. I am referring to stations like mine which have only one transmitter far removed from either 640 or 1240 in our normal operating frequency, thereby making many changes necessary. It is of the utmost importance for the transmitter to be changed over as quickly as possible and to be ready to transmit Civil Defense programs, as we will have only 10 to 15 minutes warning time. Is your procedure to change over the transmitter in clear, concise instructions, easily accessible to perhaps a new man on duty at the time of an alert? They should be! Another point to make is to not always let it be the maintenance man who changes the transmitter over to Conelrad and to check it out. Each man should be required to change over the transmitter once a week or at least once a month, either before sign on or after sign off, including switching over to the power unit until they can do it blindfolded, so to speak. I know of ten men right now who would take at least 10 minutes reading the instructions before starting to change over, because this is always done by the maintenance man month in and month out, until they tend to forget this important phase of operation. Many lives will depend upon those ten or fifteen extra minutes that it will take to resume broadcasting on the Conelrad frequency. There will be many people who will not have heard the actual alert given on the TV or radio stations but upon hearing the sirens will turn to their radio to find out what is happening. If Conelrad is silent too long, these people will not have any time to prepare themselves. Frequent drills by all the stations' personnel is necessary to bring your time of change-over down to the minimum.

While there are many in the broadcasting industry who feel that Conelrad is unoperative, it will have to be agreed that this system is better than none. After a few meetings with your local Civil Defense officials, you will find how frustrating and unthankful their tasks are and how much they desire the cooperation of the stations involved in Conelrad. It is imperative that the Chief Engineer know and fully understand the over-all plan of Conelrad for your city. I hate to admit it, but the RACES organization of the ham operators seems to be more organized and efficient in their part of the Conelrad system than the broadcast industry. In my town of Birmingham, Alabama, there is such close cooperation between the Civil Defense officials, the Conelrad stations and the RACES organization, that we have today one of the finest networks in the country in Conelrad, and we are currently in the process of providing each Conelrad station with mobile units so that Civil Defense headquarters will have two-way communications to the Conelrad stations by-passing the use of telephone lines. The telephone lines between key stations and Civil Defense Headquarters will remain in use, however. During the baseball games last summer, I devised a memo alarm for alerting the announcer of upcoming cues. This alarm was used on the telephone line. It would operate as an alarm and would double as a code devise between the two points. A circuit such as this has no effect upon the impedence of the line nor will it cause any interference to a program that is being transmitted. We used to feed code to the announcer when we used it at the baseball site at the same time the sportscaster was giving a play-by-play account of the game. It also told us that the telephone line was still connected after several days of not using the line, without having to send a man to the park to check out the loop. This type of alarm is used most effectively on the key station's audio loop to Civil Defense headquarters. Let me explain in detail. The cathode of the trigger circuit tube is divided evenly through two 5800 ohm resistors to each side of the line at the studio of the key station, and at Civil Defense headquarters' end you come off each side of the telephone line through two 3300 ohm resistors through a push to break push button switch to the main ground. The B minus of the trigger circuit tube is also connected to the main ground. This is the way the trigger circuit alarm would work. The cathode is grounded through the telephone line drawing current through a plate load relay. Positive voltage is applied to the grid to nullify the cathode bias developed. Should at any time the telephone line between the key station and Civil Defense headquarters be opened or disconnected, the cathode circuit of the trigger circuit tube would be open, causing no plate current to flow, de-energize the relay, and ring an alarm or turn a light on in the studio, bringing it to the attention of the operator on duty so that he could take immediate action to have the line repaired. This type of alarm for the telephone loop insures the key station that the line has not gone out on the day after an engineer checked it out, thereby having three days go by before it normally is found out. The key station never worries on this point, as to whether the line is good. There are many other items that should be covered, but my time is limited.

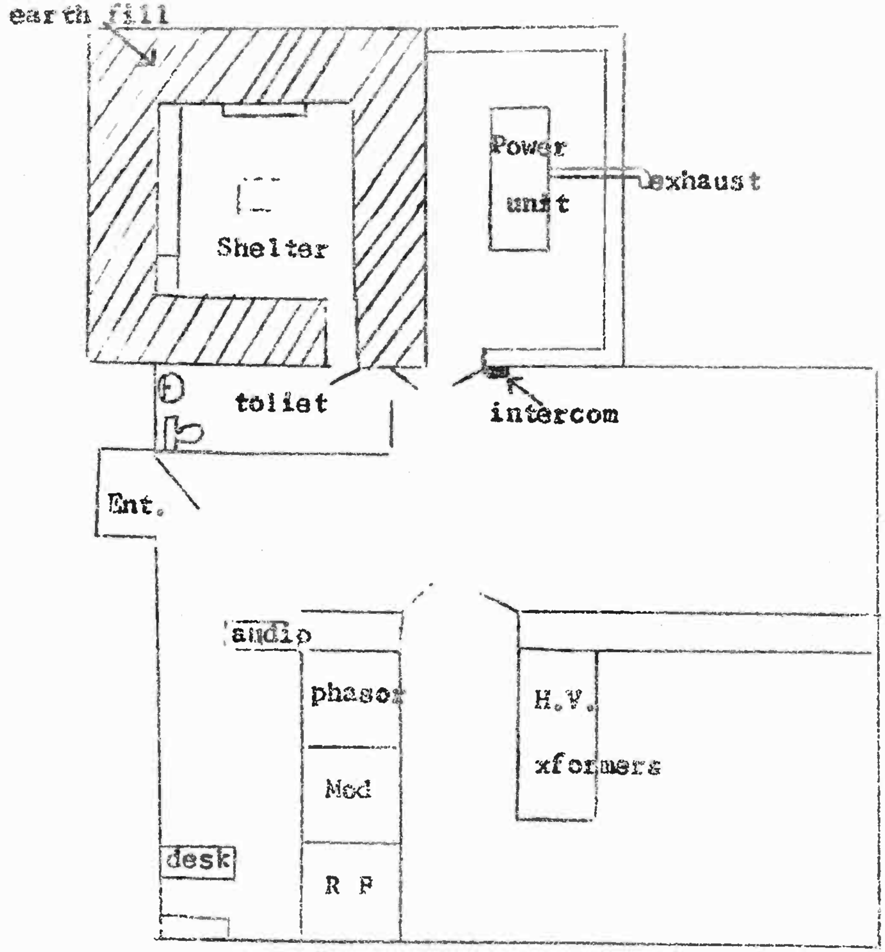
I hope I have enlightened some of you to the necessity of having emergency broadcasting facilities ready for Conelrad in the event they are ever needed. And we have come dangerously close to needing them several times in the past two years. I hope we never need them, but we must be prepared and stay prepared as long as the Sword of Damocles hangs over us.

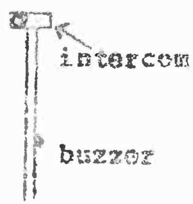
Let me recap some of the actions to take. First, meet with your Civil Defense officials and work out an acceptable plan of action for both of you. Plan your shelter carefully as to the size you will need, the amount and type of equipment that is to go into the shelter and, above all, make your transmitter as simple as possible to convert to the Conelrad frequency and instruct and train your men until they can perform the duties required of them with the utmost speed and efficiency.

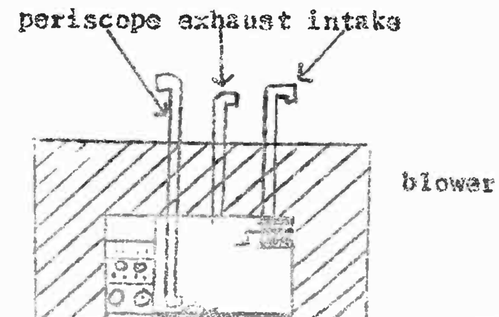
It is one of the best insurances that this nation has of maintaining its heritage. Thank you very much.



R1 & R2..5800 ohm ½W
R3 & R4..3300 ohm ½W
R5........1000 ohm 1W
R6........1 Megohm 2W
RL........Plate load relay
L1........25Watt 115vac
B.........Western Electric
buzzer type 7EW
S1........Push to break switch







Talk before the National Association of Broadcasters at Their Annual Convention in Chicago, Illinois. The Subject is "How to Improve the Quality of Broadcasting Stations", by Frank H. McIntosh, McIntosh Laboratory, Inc.

There is little doubt that the quality of broadcasting stations should be improved. We will try to outline the need for this improvement and just what improvements should be made. Along with this must be the recognition of the need for good quality and it must prove to be a commercially worthwhile thing to do.

The ability of the ear to hear distortion is almost unbelievable. It has been proved time and again that one-half of one percent harmonic distortion is detectable in some program material, including music, orchestral works, and the solo instruments. We know for a fact that 0.2% is discernible on an A-B tone test basis. We have some difficulty in definitions because when we say distortion we are referring, in this case, to harmonic distortion although there are forms of distortion known as intermodulation, phase, impulse and transient. Undoubtedly, the detectability of the distortion, as mentioned above, is probably due to the attendant intermodulation distortion more than it is to the harmonic distortion as this harmonic distortion usually just enriches the tone by adding harmonics.

One of the factors of consideration is the more than two and one-half million homes equipped with sound systems actually delivering outputs with low orders of distortion. Since there is this market already looking for program sources and having to rely, for the most part, on their own sources, such as records, tapes, or a combination of both, it is a large audience to reckon with from a broadcast operator's standpoint. It is much easier for the listener to tune in a station than to use his own sources. He will do this if that station has considered its program content and has taken the trouble to develop a really clean output signal so that the quality, which may be on the records or tapes he uses, is fully realized in the transmission medium.

In the old days of broadcasting it used to be the rare thing to find a radio receiving system that was as good as the broadcasters. Now today, believe it or not, it is rare indeed to find a broadcasting station as good as many of the receiving systems. This is a turn of tables and certainly should not exist. It is particularly deplorable since the cost of actually cleaning up and providing the quality performance of the station is not a major investment of capital.

Based on the requirements of the FCC, especially for AM stations, the broadcasters are to be congratulated on the performance of their stations. I don't believe there are any stations in America operating today as badly as the FCC specifications for AM will permit. This may not be so on some particular transmissions but generally speaking the basic equipment far exceeds the FCC AM requirements. But, of course, this is not good enough. In the matter of FM, however, this is not true. The FM broadcasting is required to provide a demanding type of service under the FCC specifications. It probably can be said here that there are not very many stations that (considering every element in a transmission path) fully satisfies this specification.

The job of solving the distortion and improving the quality of the broadcast station requires a detective type of approach. Every circuit, down to the microphones and the pickup units or tapeheads, should be investigated to see whether or not they, in fact, do perform with a low order of distortion output. This should then be followed on through the audio equipment used for mixing and the line equipment used between the studio and transmitter, if they are not located adjacent one to another. The modulation system should be rechecked and the percentage of modulation versus distortion and frequency should be rechecked.

It has been a mystery to me as to why more stations and more equipments aren't specified to operate below 50 cycles. There are indeed a large number of components in a broadcast system that are rated down to 30 cycles or so but generally speaking transmitters, particularly the AM variety, are not. These desirable low frequencies properly transmitted might require some changes in the power supply units or the type of modulation transformer used or other areas affecting the low end of the audio spectrum. The high frequencies are important too and should be carefully investigated to assure an overall flat response to include the maximum frequency for which the transmitter is capable. The aim which we would like to see would be as follows: frequency response 20 to 20 KC $\pm$ 1 db maximum, distortion well below 1% at 90 to 95% modulation at any of the above frequencies. Signal to noise ratios 60 to 80 db.

As a matter of something to shoot at, we might discuss a bit what has happened at a number of stations, in particular WLW, a case with which I am familiar. The overall system there from microphone to antenna output is flat from 20 cycles to 20 kilocycles on the AM station and delivers its full rated power output up to 100% modulation at less than 7/10% distortion at any frequency within this range. Now in order to get a 50 kilowatt station to do this, it has required some rather diligent and conscientious investigation into the limitations and capabilities of various components in the system. They have used a special modulation technique succeeding in doing a very good job. They have also succeeded, surprisingly enough, in creating quite a substantial impact on their audience in the radio field although the listeners themselves have not changed their sets. They may be using receivers that are indeed very much inferior to the quality of the transmitted signal.

This brings up one of the pecularities of distortion and its effect on the ability to hear it. It seems that one set of distortion is not masked by another set of distortion from another source, rather that it is additive so that each improvement in one part of the system can be heard immediately. For instance, if you improve your amplifier and use your present loudspeakers and have the same program source, you will hear right away a difference in the overall performance, all to your liking. Then again when you improve the loudspeaker situation, you will find still an additional improvement, etc. So every element that you add to improve the quality of your radio station will come to your attention if you are an attentive listener. You may even get letters of the sort which ask "what in the world have you done to your station - it sounds so much better?"

In order to get some incentive to go ahead and do something about the system, it would be well for you to learn more about the results that WLW has had and the benefits that they have reaped, even commercially, from this procedure.

First, I would recommend that you acquire at least one, perhaps a number, of high quality monitoring facilities. Get a good three division speaker system, a good amplifier; then start listening to your various circuits. Augment this with a systematic study with a suitable distortion meter and an audio oscillator with low distortion output. Then test your whole system and just "comb" it out in every conceivable direction. Make a chart on the various measurements and limitations that you discover as you make this investigation and then as you get time, one by one, work on each area which you can solve as either money becomes available or time to clean up the difficulties.

One of the things which has bothered me for many years has been the limitations of preamplifiers as used in studio pickup systems. To provide a better signal to noise ratio almost everyone uses "high level" mixing. The mike is connected to an input transformer, thence into the preamplifier, then the mixer where the volume is controlled.

We provide enough gain to give required output for the lowest mike level considered usable but seldom think of providing enough power capacity in the mike transformer and preamplifier to handle the loudest sounds to which the microphone is subjected. Consequently, in actual practice or perhaps almost all the time, peaks are severely "clipped" by the above devices limiting the realism of the recording or reproduction. Few people seem to realize that microphones operating at 50 to 250 ohms output are capable of putting out 0.5 to 1 volt for loud passages of music or vocal renditions. Since preamps have gains ranging generally from 35 to as high as 50 db, it doesn't take much to figure that a very substantial voltage output from the preamplifier is required if "clipping" distortion is to be avoided. Yet preamps are rated at -20 db maximum. For a preamp having 40 db gain (100) it's conceivable that a quality system should provide for 50 to 100 volt swing in the output circuit of such a preamplifier.

We, some years ago, brought out a 60 watt audio amplifier which we thought was pretty good and which had measured well under one-half of 1% from 20 cycles to 20 kilocycles. We sent one of these units to a friend of ours in Saukville, Wisconsin, who is quite a critical listener. He called us upon its arrival and his test stating that he was very unhappy with the amplifier and it certainly didn't sound right so we asked him to send it back. We went over it and found that it met the one-half percent distortion requirement but it was slightly higher at frequencies around 120 cycles which is the ripple frequency of the power supply. Upon investigating this with a wave analyzer, we found that the distortion here was very slightly above what it was over the rest of the spectrum. We had some doubts as to whether anyone could hear such a thing as this and so we actually fixed it by including a choke coil and returned the amplifier to him. He immediately indicated that now we had done a job and he could hear the difference very easily. This modification, of course, became standard in this amplifier thereafter.

The ability of the ear to hear is unbelievably amazing. A conductor can hear an off beat instrument, one slightly off tune, or not in time. You can discern these small differences in characteristics of sound. You can identify so readily a person's voice with which you are familiar. An absolute analysis of these voices is so similar to other voices that it would be almost impossible to identify differences technically. This points up the fact that maybe we better pay a lot more attention to what our ears tell us than we have in the past and devise maybe technical means to tell us the same story that our ears tell us.

An approach to this is to use burst generators, pulses or square waves, and view the output of the element under test by a quality oscilloscope and clean the apparatus up so that any form of signal within the maximum ratings does not cause any noticeable differences in the observed results over the input signals.

There are several interrelationships in speech and sound music transmission which might be worth thinking about. One is that this method of rating distortion or performance of a transmitter or speech input equipment on a gain frequency basis is pretty well outmoded because any amplifier which is low in distortion over the audio spectrum is so flat from a gain frequency standpoint that it can hardly be measured. One hundredth of 1 db variation 20 cycles to 20 kilocycles is a normal amount of variation to be expected from a hi fi high quality amplifier that is made today. It might be well to point out that generally speaking if an amplifier is 3 db down at some point then it has a phase shift of something like 45° and if an amplifier has one-half of one percent distortion or less over its spectrum, the phase shift is very likely less than 10 or 15°, so you can see by this corollary that the gain frequency characteristic has to be extremely flat to be a good amplifier from a distortion standpoint. This is primarily due to the fact that stabilized negative feedback is used to minimize the non-linearities of amplifying systems. Since the feedback effect is a function of the cosine of the phase angle of the harmonic involved, it doesn't take very many degrees of phase shift to render the feedback on a cosine basis useless. For instance, 45° phase shift would make feedback about half as good as it is with zero phase shift. Ninety degrees of phase shift, at some harmonic, would make the feedback zero and beyond that it would probably make the measurement of distortion worse. This is why amplifiers which are only used for audio purposes have such tremendous bandwidths. For instance, our standard power amplifier made for the hi fi field has a bandwidth of something like 200 KC although the range for which we specified is only 20 cycles to 20 kilocycles. These bandwidths are not stunts nor done just to show how good we can make amplifiers but it's found to be necessary in order to achieve the low distortion at the highest frequencies.

Unfortunately, just the general addition of feedback is not a cure-all for amplifier distortion. Amplifiers having high levels of feedback must be extremely stable in order not to show transient distortion or other instabilities. This is probably the most difficult to measure and certainly the most common cause of unsatisfactory reproduction. We call this distortion transient for want of a better term. It usually can be seen on oscilloscopes or measured on some types of distortion equipment by utilizing pulses rather than steady tones in the test mechanism. A burst of sound, for instance, will very often cause a circuit which has an unstable characteristic to "ring" developing unwanted wave characteristics. These are the subtle things which are, as I say, difficult to put your finger on but which when eliminated result in a clear, brilliant and realistic reproduction of sound which is so satisfying when listening to fine music.

One more suggestion, once you have found the limits of the overall system, do not put into it any frequencies at levels which it will not handle properly. This procedure will reduce intermodulation involving frequences and levels in the non-linear positions of operating elements.

We are finding in our own experience that the public is getting more and more critical of our equipment and others who manufacture in our field and that they are becoming very wise in their ability to detect a good and a bad transmission. Therefore, we are convinced the only way to solve the problem, to keep their interest up, and to hold on to the market that we are after, is to constantly develop more and better ways to reproduce sound with less and less artificiality coming from things introducing distortion.

It is well to remember that sound alone is the all important link between the broadcaster and the listener. The degree to which you appeal to the listener prevents him from tuning out your station or switching off the set. What he hears, both as to what the content of the message is and how well it comes over, is all the control you have, is really the life line of the broadcaster.

In connection with stereo we have had years of growth and growing pains and consequently there have been a lot of mistakes made by suppliers and manufacturers. The problems are not completely solved but the quality of this information and program source is getting better and it is certainly to the point where it is worthy of consideration of broadcasters. While the introduction of stereo at your stations involves considerably more than just improving the quality, the effect of the stereo system will be much enhanced if the quality is also improved at the same time and it also becomes even more important to have the quality better if a monaural signal is going to hold the listeners' interest, particularly against stereo sound.

NEW APPROACH TO T.V. STUDIO LIGHTING LEVELS

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Studio lighting levels are usually discussed and measured in terms of the footcandle, which is a measure of incident light. It has long been recognized that footcandle densities do not indicate reflectances of the various components that constitute the radiant energy images picked up by the television camera. However, a footcandle meter in the hands of an experienced lighting technician can be very useful at times, not only for judging incident lighting levels but for helpful information concerning the amount of light reflected from certain surfaces.

BRIGHTNESS REFLECTANCES

Since the camera is concerned only with brightness reflectances, more accurate information is obtained from brightness meters which show the footlambert values of light reflected from the scene components towards the camera. The footlambert is sometimes called the "apparent footcandle" since it represents an incident footcandle multiplied by the reflection factor of the surface. Reflection factors of course vary widely, and skin tones for example usually have a reflectance of 40-50%. Thus an incident density of 100 footcandles would normally illuminate skin tones to a brightness of 40-50 footlamberts.

FOOTCANDLE READINGS

Desirable footcandle levels for a studio setup vary considerably depending not only upon the type of camera tube and selected lens stop but among other things upon the brightness and hue of the various scenic components, the degree of dramatic effect required and the individual technique of the lighting director. The speed of movement in the action or in the panning and tilting of the camera may also be a factor, as for example with the vidicon tube when the footcandle density may have to be lifted say from 50 to 250 footcandles in order to prevent blurring of moving parts through "lag".

In consequence various footcandle levels are cited as normal for studio lighting, examples being 50 - 150 footcandles for black and white with the image orthicon tube and 20 - 250 footcandles for the vidicon tube. It is realized however, that the most desirable levels for any particular scene are determined by a number of factors as shown above.

SPECTRAL DISTRIBUTION

Unfortunately footcandle readings fail to give important information concerning the spectral distribution of the incident light and furthermore in T.V. work can be misleading inasmuch as they are related to human vision and not to the response characteristics of the camera tube. As far as footcandles are concerned, 100 f.c. of incident light with a color temperature of 2900°K is the equal of 100 f.c. of light of 3400°K, whereas every lighting director knows that the latter would illuminate a blue backdrop to a higher brightness than the 2900°K illumination. In other words the same footcandle levels from lights of different color temperature are not necessarily equal in illuminating power, because of difference in spectral distribution.

An understanding of the ways in which various spectral distributions of incident light affect the reflection brightnesses of components in the set and therefore the responses of the camera tube, leads not only to effective picture composition but opens the way for important economics in equipment and operating costs.

It is proposed in this paper to consider these matters in further detail and to show how control of the spectral distribution of incident light can be used to regulate reflective brightnesses of colored surfaces.

THE LUMEN

First it is helpful to remember that the unit of luminous flux is the lumen, which corresponds to the flux received by a surface of one square foot every elemental part of which is one foot distant from a light source of one candlepower. The illumination received at this surface is known as the footcandle. Thus the footcandle equals a flux of one evenly distributed lumen per square foot.

The light output of lamps is usually catalogued in terms of lumen output, but no information concerning spectral distribution is given except that in the case of many photographic and studio incandescent lamps the color temperature ratings in degrees Kelvin are stated.

COLOR TEMPERATURE

In a scientific sense a kelvin rating is not the equivalent of a specific spectral distribution, and the spectral distribution of a lamp with a color temperature rating in °K can be matched by any one of an unlimited number of other spectral distributions that may merit the same Kelvin rating.

This is evidenced by the fact that the standard cool white and deluxe cool white florescent tubes have the same Kelvin rating whereas their spectral distributions are quite different.

However in the case of the specific type of light source represented by incandescent tungsten filament lamps the spectral distributions of light output do remain closely related to Kelvin ratings, and these color temperature ratings are helpful as means of reference to the spectral distributions of the lamps in question. For the remainder of this paper therefore, color temperature ratings will be used as indicative of the associated spectral distributions of incandescent tungsten filament lamps.

EYE SENSITIVITY

Reverting to the lumen it is helpful to know that the lumen output of a lamp is computed by multiplying the output of radiant energy at each wavelength in the visible spectrum by the factor of eye sensitivity at that wavelength. The human eye does not respond equally to every wavelength as will be seen from Fig. 1 so the lumen output of a source is determined to a considerable extent by the manner in which the radiant energy output is distributed over the wavelengths between 380 - 760 millimicrons. If all the radiant energy were emitted at 555 millimicrons the source would have a very high lumen rating since this is the point of maximum eye sensitivity. The same amount of radiant energy distributed over the whole spectrum would have a lower lumen rating, since at all wavelengths other than 555 millimicrons the factor of eye sensitivity is lower, as shown by the luminosity curve.

CAMERA TUBE SENSITIVITY

Now the spectral sensitivity characteristics say of a type 5820 image orthicon tube are not the same as those of the human eye as shown by curve A in Figure 2. However, by means of a filter the curve is corrected to correspond to curve B. While this is closer than A to the human eye sensitivity curve as seen at C, none the less it differs in response, and is more sensitive to the violet, blue and green portions of the spectrum.

To correctly estimate the value of incident illumination for the 5820 (or any other) tube it would be desirable to replace the lumen as the unit of luminous flux with a new unit of measurement computed by multiplying the radiant energy output at each wavelength by the response characteristic of the tube at that wavelength. Otherwise the unit of measurement for the density of incident light (at present the footcandle) will not accurately indicate illumination values as related to a camera tube response.

ADJUSTED FOOTCANDLE

It is possible to achieve corrected measurements as above in some instances by fitting Illumination meters with correction filters as for example with the Weston No. 756 Illumination meter which can be fitted with a filter to give readings based on the response of an image orthicon tube instead of upon the sensitivity of the human eye. Other tubes with different response characteristics would of course require suitable correction filters.

The scale readings thus obtained no longer correspond to footcandle values, since they are based on tube response rather than the sensitivity of the human eye. To avoid confusion as to what to call this new unit of incident lighting, the term "adjusted footcandle" will be used in the remainder of this paper.

COLORED SURFACE REFLECTANCES

Reverting to spectral distribution, the only practical reason for providing incident light is to obtain surface reflections that constitute a radiant energy picture that may be picked up by the camera. What is basically important is not the incident light as such but the radiant energy distribution it causes to be reflected from surfaces seen by the camera.

Now while variations of spectral distribution in the incident illumination are unimportant when the reflective surfaces are white or neutral gray, such variations can be very important in the case of colored surfaces - both for black and white and for colored television. This is because colored surfaces selectively reflect radiant energy of certain wavelengths according to their hue and chroma. A light source rich in energy at wavelengths that are reflected will provide brighter surfaces than other sources with less advantageous spectral distributions. Thus the blue backdrop mentioned earlier will be brighter when illuminated by a 3400°K source, than a 2900°K source giving the same footcandles, because a greater proportion of the radiant energy of the former is in the blue portion of the spectrum.

Since neither footcandle nor adjusted footcandle readings of incident light would indicate even a considerable difference in the reflectance brightness of a colored surface due to color temperature differences, it is apparent that such footcandle readings are not a reliable indication of colored surface reflectances. It would be necessary to take brightness measurements of the surfaces in question with a brightness meter fitted with a suitable corrective filter, and to get readings corresponding to "adjusted footlamberts", in order to obtain figures of exact value. Until this is done meter readings may only be of mathematical value in the hands of an experienced lighting technician, and the empirical method of lighting a set with an eye on the T.V. monitor will continue to have much to recommend it.

RELATIVE ENERGY OUTPUT

The differences between spectral distributions of lamps of the same wattage but different color temperature ratings is shown in Figure 3. Many interesting facts may be deduced from these curves, including the following:

(1) The light output becomes greater as the Kelvin rating is increased.

(2) The increase in output becomes relatively greater towards the violet end of the spectrum.

The relative energy outputs of some of these ratings may be compared as follows:

Milli-microns	2700°K	2900°K	3000°K	3200°K	3400°K
680	63	88	98	116	132
640	52	75	85	104	120
600	40	61	71	90	108
560	31	50	58	75	91
520	21	36	43	58	74
480	13	25	30	42	56
440	7	14	18	28	39
400	5	8	10	16	24

From these figures it will be seen that a blue backdrop having a dominant wavelength of 440 millimicrons with a high degree of purity, will receive twice as much illumination at this wavelength from a 2900°K source as from a 2700°K source. Use of a 3400°K source of the same wattage would provide four times as much light at 440 millimicrons. Now since these increases are the result of spectral distribution alone, and wattages are equal, one lighting fixture using a 3400°K source of given wattage could replace four lighting fixtures of the same wattage but with 2700°K sources.

Taking another example, if the illumination on the same blue backdrop is provided by twelve fixtures with 2900°K sources, then this can be matched by six fixtures of the same wattage but with 3200°K sources.

A green backdrop having a dominant wavelength of 520 millimicrons or an orange at 600 millimicrons - with a high degree of purity - can each be illuminated as well with eight fixtures with 3200°K sources as with twelve fixtures with 2900°K sources and the same wattage.

Paler colors with a lower degree of purity do not respond so sharply to differences in radiant energy output at the dominant wavelength but according to the loss of purity would tend to respond more to the average increase in total light output of the higher kelvin rated source.

LAMP LIFE

However, lamp life becomes shorter as Kelvin ratings are raised, so that the economies effected by using fewer sources of higher Kelvin rating are offset to some extent by more frequent lamp replacements. For example, a G40 type 1000 watt bulb with C13 filament is rated for 22500 initial lumens with a life of 200 hours at 3000°K, compared with 28000 lumens with 35-50 hours life at 3200°K. In spite of the shorter lamp life there are numerous instances in which it is definitely advantageous to go to higher Kelvin ratings, and there are many standard lamps available for use in T.V. lighting equipment rated say at 3200°K and 3350°K.

NEW APPROACH TO STUDIO LIGHTING

The author suggests that T.V. studio lighting should be approached in a manner that will allow the spectral distribution of the light sources to be varied as required, so that advantage can be taken of such factors as higher output, change of spectral distribution or longer lamp life. Intelligent control of such factors can result in important economies in equipment and operating costs.

One method of achieving this control is to use means of varying the voltage to the various lamps. An increase in voltage raises the color temperature rating, increases light output and shortens lamp life. A voltage decrease lowers the Kelvin rating, reduces light output and lengthens lamp life. In each case there are changes in the spectral distribution.

Standard studio dimming equipment will reduce lamp voltage, so there is no difficulty in reducing the operational color temperature of light sources. When it is desired to operate at Kelvin values that are higher than the normal rating of a lamp, one of the following methods can be employed:

(1) Use of 3350°K or 3400°K lamps as standard in the lighting equipment, (relying on voltage reduction to reduce the Kelvin ratings to a lower level as normal).

(2) Providing means to increase the voltage above the normal 115-120 volts to, say 140 volts.

Whichever of these two methods is preferred it may be desirable for the dimmer operational handles to be provided with means to prevent the lamps from being used at the highest Kelvin rating without some specific action by the operator. This would help to prevent the lights needlessly burning at shorter life values through careless movement of the handles.

Alternately pilot lights of different colors could show in what Kelvin range the lamps are being used.

The lamps normally used in T.V. studio work are available with Kelvin ratings up to 3350° or 3400°K. For example, the PS52 lamp often used in scoops is available at 2850°K (1500 watts - 1000 hours - 27500 lumens) at 3200°K (1500 watts - 100 hours - 40000 lumens) or 3350°K (2000 watts - 15 hours - 65000 lumens). This makes the first method outlined above, an immediate possibility for most existing installations.

Adopting the method of lamping up with the highest Kelvin rated lamp and assuming a normal lamp socket voltage of 114 volts then the performance characteristics of the 2000 watt 3350°K lamp for example could be varied by voltage reductions as follows:

Voltage range	70-114 volts
Color temperature range	2800 - 3350°K
Watts	900 - 2000
Lumen output	10500 - 65000
Lamp life	1500 - 15 hours

The second method of using a voltage step up, will cause one important difference, namely that the normal wattage of the lamp will be increased as well as its color temperature. Thus a standard 1000 watt 3000°K lamp will become a 1400 watt lamp if it is raised to 3200°K by means of additional voltage. This would increase the radiant energy output at various wavelengths above the figures given earlier in this paper since these are based on the light output of lamps of the same wattage.

Extending the curve shown in Fig. 4 a little at either end and assuming a normal lamp socket voltage of 114 volts, then an increase or decrease of 26 volts will give a voltage range of 88 - 140 volts. This will enable a 3000°K lamp to be operated within a range of 2750 - 3200°K. The performance characteristics of a 1000 watt lamp producing for example 21500 initial lumens with a 200 hour life, would then range approximately as follows:

Watts	650 - 1400
Lumen output	8600 - 43000
Lamp life	2000 - 40

With either of the two methods it is possible to use all the lighting units for a scene exactly as set up, but to operate them at a lower voltage during long periods when cameras are not in use. This will result in longer lamp life and can be the means of appreciable economies in lamp replacement costs.

It may be remarked that apart from the concepts of varying voltage to change color temperative as above, there is a growing tendency in some quarters to favor the basic use of 3200°K lamps instead of 3000°K lamps, especially for color television work.

In conclusion it is hoped that the information concerning spectral distribution and color temperature changes given in this paper will be helpful to those engaged in studio lighting.

The evidence seems clear that there are considerable advantages, both technical and economic in controlling spectral distribution. Intelligent use of the resulting variables can help to develop the art and science of television studio lighting. Little has been said in this paper about the advantages for accurate color rendition in color T.V. by controlling spectral distribution, as this is the subject for another paper, but it is obvious that these are important advantages to be gained in this direction.

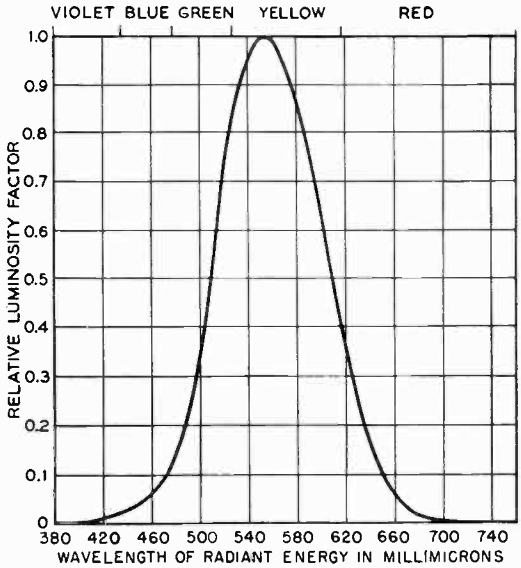

Fig. 1. The standard (CIE) luminosity curve, showing the relative sensitivity of the human eye to different wavelengths of radiant energy. (Courtesy *IES Lighting Handbook*)

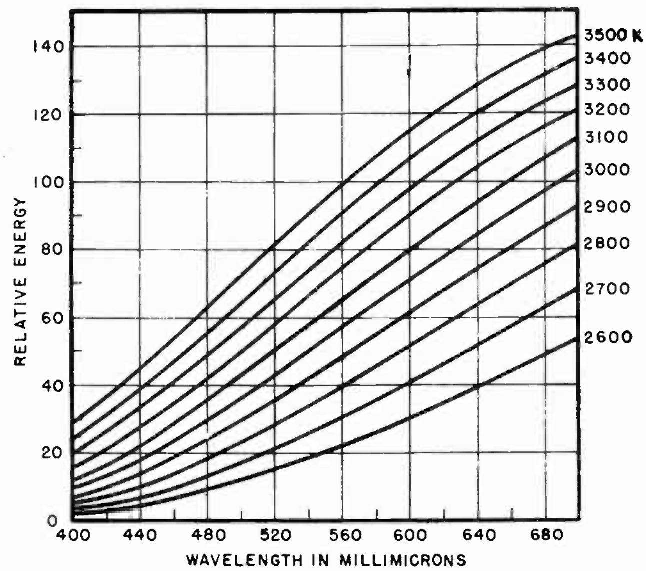

Fig. 3 Spectral energy distribution in the visible region from tungsten filaments of equal wattage but different temperatures. (Courtesy *IES Lighting Handbook*)

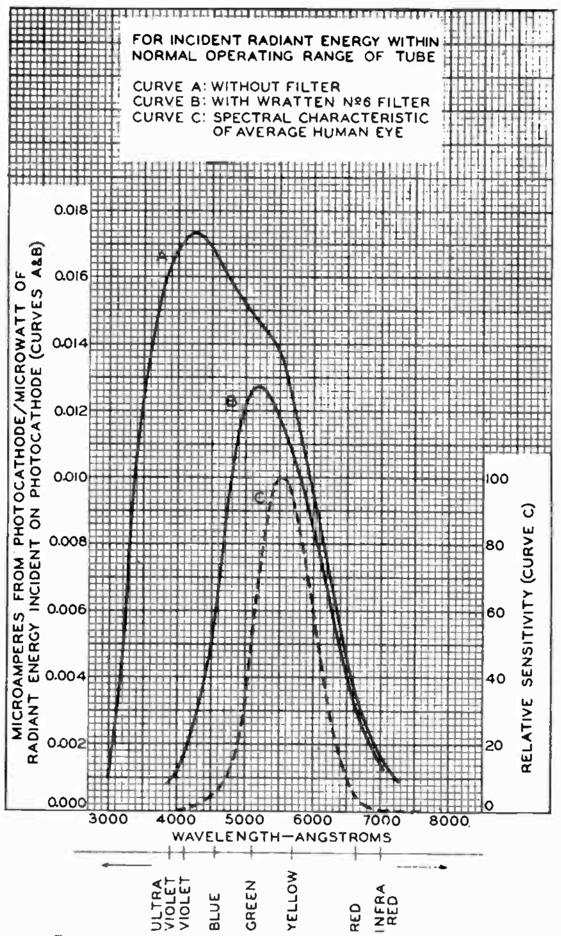

Fig. 2 Spectral sensitivity characteristic of Type 5820 with and without filter. (Courtesy RCA Electron Tube Division, *5820 Image Orthicon*)

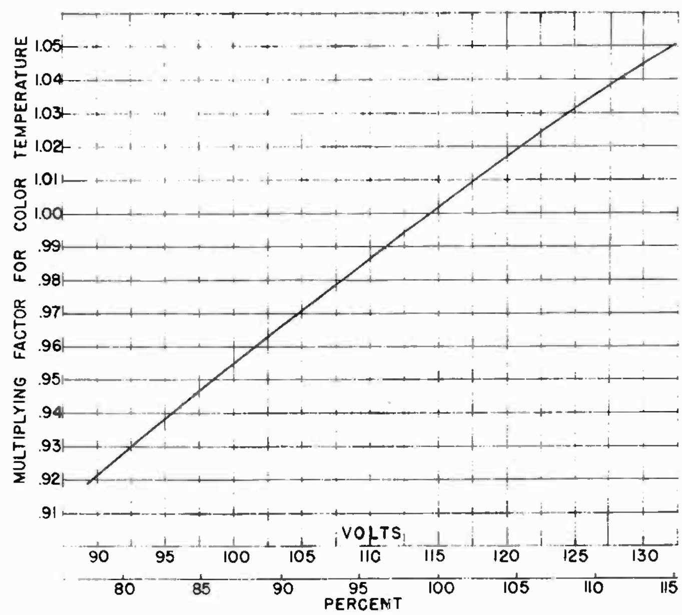

Fig. 4. Variation of color temperature with change of voltage — 100- to 130-v types.

(Courtesy S.M.P.T.E. Journal)

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Characteristics and Mode of Operation of Image Orthicons

by

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Characteristics and Mode of Operation of Image Orthicons

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During the past three or four years the television broadcast industry has had to cope with new situations and new requirements for programming which have changed established operating techniques and ground rules. The broadcaster is now required to operate under conditions that were previously considered marginal or impossible and to produce pictures of higher quality with less effort and complication.

The character and quality of the picture from a TV camera primarily depend on the design of the image-orthicon tube and the manner in which the tube is operated. The performance of the camera tube is in turn controlled by the camera design, the flexibility of the camera controls, and the lighting level and contrast ranges of the scene. The problem of predicting and controlling the character of a television picture in terms of resolution, gray scale, signal-to-noise ratio, and contrast range is related to three factors: first, the characteristics of the camera tube, such as sensitivity, target mesh spacing, and size; second, the operating target voltage; and third, the type of lighting and the "exposure" presented to the camera tube.

The target voltage of the camera tube influences the character of the picture, the gray scale rendition, and the latitude of exposure that is possible with the tube.

Physical Characteristics of Television Camera Tubes

Two significant factors of the camera tube design control the quality and character of a TV picture: the target-to-mesh spacing and the target size; both are related to the storage capacitance of the tube. The target-to-mesh spacing and the size of the target determine the electron re-distribution characteristics; to some extent the size of the target also determines the resolution of the picture. A field mesh in the tube determines the beam trajectory and influences background uniformity, corner focus, and beam bending. Other features of image-orthicon tubes such as multiplier gain and photocathode sensitivity have little influence on the quality of the picture. However, the velocity distribution of the secondary electrons from the target can result in various electron re-distribution effects when the image orthicon is operated over the knee of the characteristic curve. The electron optics in the front end of the tube determine the trajectory of the re-distributed electrons. The higher capacitance tubes such as the 4-1/2-inch 7295A and 7389A image orthicons and the 3-inch 7513 and 8093A tubes have longer linear portions in their characteristics and produce a wider range of gray scale.

Operating Conditions

For factors such as resolution, gray scale, signal-to-noise ratio, and contrast range, two types of operation must be considered: first, operation with the highlights close to the knee of the transfer characteristic, and second, operation with the highlights substantially above the knee of the characteristic. The tube performs reasonably well on the linear portion up to the knee. The signal-to-noise ratio and contrast range vary as the square root of the capacitance of the tube or the target voltage on the tube.

When the image orthicon is operated above the knee of the characteristic, various effects take place. Under these conditions, the curvature of the transfer characteristic and the electron re-distribution effects become rather important. When the camera is operated with the highlights at or below the knee of the characteristic, the picture has a photographic quality; i.e., there are no exaggerated brightness distortions, black borders or, white halos. The picture is similar to the picture produced by a vidicon tube, except that it is darker because the characteristic is essentially linear and does not correct for the "third power" response of the picture tube. When the tube is operated with the highlights above the knee, the effective transfer characteristic more closely approximates the picture-tube characteristic and the tonal values of the picture on the monitor are close to their original values.

Operation above the knee of the characteristic has both advantages and disadvantages. Although relatively little control is required on the camera if the exposure is greatly over the knee, an excessive amount of black border appears around white objects, unnatural shadows appear in the picture, and facial tones become distorted. A moderate amount of this re-distribution effect is not only tolerable, but desirable because it makes a picture appear somewhat sharper and clearer and compensates for some of the deficiences in the television system.

Fig. 1 shows that the eye has difficulty distinguishing the differences between steps when the transition is eliminated. In the image-orthicon, electron re-distribution enhances the boundary between areas of different brightness. When the camera tube is operated slightly over the knee, the signal-to-noise ratio appears to improve. The actual measured signal-to-noise ratio does not change substantially, but the picture appears generally brighter and the noise becomes less noticeable to the eye in the brighter areas of the picture. It is generally conceded that the best picture can be developed by an image orthicon when the highlights are far enough over the knee to obtain some exaggeration of boundaries and a moderate amount of dark halo, but not so far above the knee as to result in flat pasty white looking facial tones, brunettes turning into blondes, and excessive dark halos around brightly illuminated objects. If these effects are not considered objectionable, no controls are necessary in the system. The camera lens is merely opened fairly wide, plenty of light is poured onto the scene and no drastic changes occur as the camera is panned to different parts of the studio.

In order to produce a consistent picture quality with the highlights exposed to achieve a pleasing picture having no gross exaggerations of the actual scene, it is necessary that a number of things be under control. The basic operating control that should be exercised is that of lighting. (It is not advisable to adjust the tube voltages to compensate for varying lighting conditions or to affect camera matching.)

Lighting can be controlled by measuring the light at all portions of the scene, taking into account the reflectance of the scene, and adjusting the lighting so that, as the camera pans from point to point, the amount of light reflected from the scene is substantially the same for all of the highlight areas. In this lighting procedure, the shadow areas should also be illuminated with fill light so that it is not necessary to over-expose the tube to bring out details in the shadows at the expense of proper highlight exposure.

No television system is capable of reproducing images as the eye sees them. The eye can easily distinguish a contrast ratio of several hundred to one but it is difficult to pass such a contrast ratio through the television system without major distortions. The picture on the receiver can be made to appear similar to that of the studio, by modifying the studio lighting; fill light is placed in the dark areas so that the contrast ratio of the scene is reduced.

If it is not possible to control the absolute level of lighting or scene reflection in each set, it is necessary to control the exposure of the camera as the camera is panned from set to set or scene to scene. Most new image orthicon cameras have a remote iris control. Such controls have been in use in color cameras for the past ten years. In color operation, this exposure-control method is mandatory. The technique is now being applied to black-and-white cameras with good results and good field acceptance.

It is also possible to pre-set enough variables prior to putting on a production so that no controls need be manipulated during the entire time the production is on the air. Operating without control during the production is possible under two conditions: (1) when the tube can be grossly over-exposed so that little change occurs in the picture as the varying lighting situations are encountered; or (2) all lighting conditions can be controlled and adjusted properly so that there are no changes necessary as the camera pans from point to point in the studio set. Present cameras and camera tubes can be operated in this manner. Because stability is built into the circuitry, the operating conditions on the camera tube do not change over long periods of time. High target-capacitance image-orthicon tubes which are capable of handling wide light ranges are also available, such as the 7295A, 7389A, 7513, and the 8093A.

The Choice of Target Voltage

One of the most potent effects on the picture characteristics of the image-orthicon tube is the choice of the target voltage. The useful target voltage for most tubes is restricted to a rather narrow range between 1-1/2 and 3 volts above the target cut-off point. However this 1-1/2-volt range of operation is quite effective in changing the characteristic of the picture. Operating with a target voltage lower than 1-1/2 volts produces a somewhat muddy and noisy picture. Operating with a very high target voltage produces exaggerated edging effects and poor resolution, particularly if the tube is not of the field-mesh design. The field-mesh design permits operation at a somewhat higher target voltage without exaggerated edges.

Operating with a high target voltage produces a long linear characteristic and is a useful technique in color camera operations. If the intent is to have the most accurate rendition of gray scale and to have a picture with a true photographic effect, the choice of high target voltage is the proper one. Under these conditions the highlights are normally operated only slightly above the knee of the characteristic curve, which becomes rather abrupt at this target voltage setting. In general, black-stretch circuitry or gamma-correction circuitry is required to produce a picture having a fairly "bright" characteristic without the undesirable electron re-distribution effect which results from over-exposure. With this type of setup, it is possible to handle a relatively wide contrast range and still produce a very pleasing picture. When image-orthicon camera tubes are operated in this manner, the lighting must be well under control. If the lighting is not closely controlled, two conditions may result: (1) as the highlights ride up and down over the knee of this curve, the average picture brightness will change fairly fast with small changes in light levels or exposure, or (2) if the tube is over-exposed because of too much studio light or if the iris is opened too wide, highlights such as facial tones will tend to "chalk out" and produce a washed out look in facial tones. However, if each location in the studio is set to the same lighting conditions and the camera is carefully adjusted to produce the best possible picture under these conditions, no difficult situations will be encountered throughout a series of shots or productions in the studio. If lighting uniformity cannot be achieved, very acceptable continuity can be obtained by "riding" the remote iris control to maintain a constant peak-signal output.

Target-Voltage Settings

Changing the target voltage from 3 volts to about 2 volts changes the character of the picture. In addition, the tube can tolerate more over-exposure without having highlight detail wash out. This condition is caused by a change in the electron re-distribution characteristics of the image section of the tube, which preserves the boundaries between areas of different brightness. This action makes the picture appear to have improved highlight contrast.

Fig.2 and 3 show this characteristic on the waveform developed from a logarithmic step chart for 3-volt and 2-volt target setup. When a 3-volt setup is used (Fig.2), the steps of the pattern are precise and have little or no tilt at operation below, as well as above the knee. When the target voltage is 2 volts (Fig.3), these steps show a decided tilt and the transition between steps is enhanced. This edge enhancement causes the picture to appear to have higher contrast, particularly in highlight details. Three-inch tubes operate in a manner similar to the 4-inch tubes when the same target voltage is used, as shown in Fig.4.

The knee does not actually become more gradual or less abrupt when operated with 2 volts set-up, but the picture appears to the eye to be more abrupt with a 3-volt target setup. At 2-volt operation, each area of brightness is more clearly set off from its surroundings. This method of operation therefore allows more latitude in exposure control and scene contrast range.

The Effects of Target Setting, Exposure, and Gamma Correction on the Picture Character

Fig.5 is a direct photograph in which the contrast is extremely high because of the subjects fair skin and jet black hair. Fig.6 shows a 5820A image-orthicon exposure at 3 stops over the knee; the subject's hair is lighter, and there are harsh contrasts around the border and unnatural highlights in the hair. Fig.7 shows a 7295A 4-1/2-inch image-orthicon picture exposed one stop over the knee at a 3-volt target voltage. The image lacks "snap" and is too dark as a result of smashed blacks. When the 4-1/2-inch tube with 3-volt target voltage is exposed 3 stops over the knee, as is the usual practice with 5820A tubes, the resulting picture is of poor quality, as shown in Fig.8. Reducing the target voltage to 2 volts and exposing about 1-1/2 stops above the knee improves the picture, although it is still slightly dark. As shown in Fig.10, when the same target voltage is used at an exposure 3 stops over the knee, the re-distribution characteristics allow the tube to handle the situation and produce a usable picture. Fig.11 was taken at the same camera setup as Fig.9 (1-1/2 stops above the knee, 2 volts on the target), but a gamma correction of 0.8 power was used in the processing amplifier to raise the average brightness.

The Choice of Proper Tube and Operating Conditions

The previous explanation of tube characteristics and other information leading to the choice of a tube and the operating conditions for any situation may seem strange when it is known that a low target voltage or the use of low-capacitance image orthicons is necessary to get a satisfactory picture when the contrast range in a scene is extremely high, such as in outdoor pickup in direct sunlight. Up to a contrast range of 50 to 1, high target voltages and high-target-capacitance tubes produce a superior picture when properly lighted and exposed. When the contrast is in the range of several hundred to one, the best procedure is to use a lower target voltage, low-capacitance tubes, or over expose and hope for the best.

Trends in Image-Orthicon Tubes

A number of trends in the broadcasting industry are stimulating new and different image-orthicon tube designs. The general demand for better picture quality as a competitive advantage has resulted in generally improved technical quality. Color programming and film programming have emphasized the difference between the conventional black-and-white television picture and other types of programming material. The increased use of tape-recorded programs in place of the relatively noise-free program produced from film has brought on the demand for improvements in signal-to-noise ratio. In addition, the photographic quality of pictures developed by vidicon film cameras and color cameras has caused a re-appraisal of the operating techniques for black-and-white studios. Automation of station operations has produced a demand for improved camera and tube performance because this method of operation requires both tubes and equipment that can be "pre-set" and operated with a minimum of skilled technical personnel.

In Europe, the demand for excellence in picture quality has encouraged the use of high-capacitance tubes such as the extremely close-spaced 3-inch and the 4-1/2-inch image-orthicon. At the high target voltages, these tubes have a long linear gray-scale characteristic which results in a generally pleasing picture without any exaggerated borders and edges. High-capacitance image orthicons of the field-mesh type are used almost universally in European studio operations. The Canadian Broadcasting Company has switched over entirely to field-mesh tubes and the high-capacitance 4-1/2-inch tubes for all studio work. In the United States, more and more field-mesh tubes and high-capacitance versions of these tubes are being used both for color and black-and-white programming. There has also been a noticeable trend in United States broadcasting toward operating camera tubes with less over-exposure so that the character of the picture more nearly approaches that of color network programs and film-originated programs. The close-spaced, high-capacitance tubes are also used to improve the quality of tape-recorded programs where noise is a perennial problem. In the future, the trend will be toward more controlled operations in the studio, pictures of better photographic quality, improved signal-to-noise-ratios, and less distortion of the picture. The image orthicon line will be progressing towards the higher capacitance field-mesh-type tubes having higher sensitivity and more uniform characteristics from tube to tube. We believe that the broadcasting industry and the camera equipment tube industry are in step along the line leading to a more simplified method of generating pictures of consistent quality.

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2. R.G. Neuhauser, "New Television Camera Tubes in Perspective" *Journal of S.M.P.T.E.* December 1961.

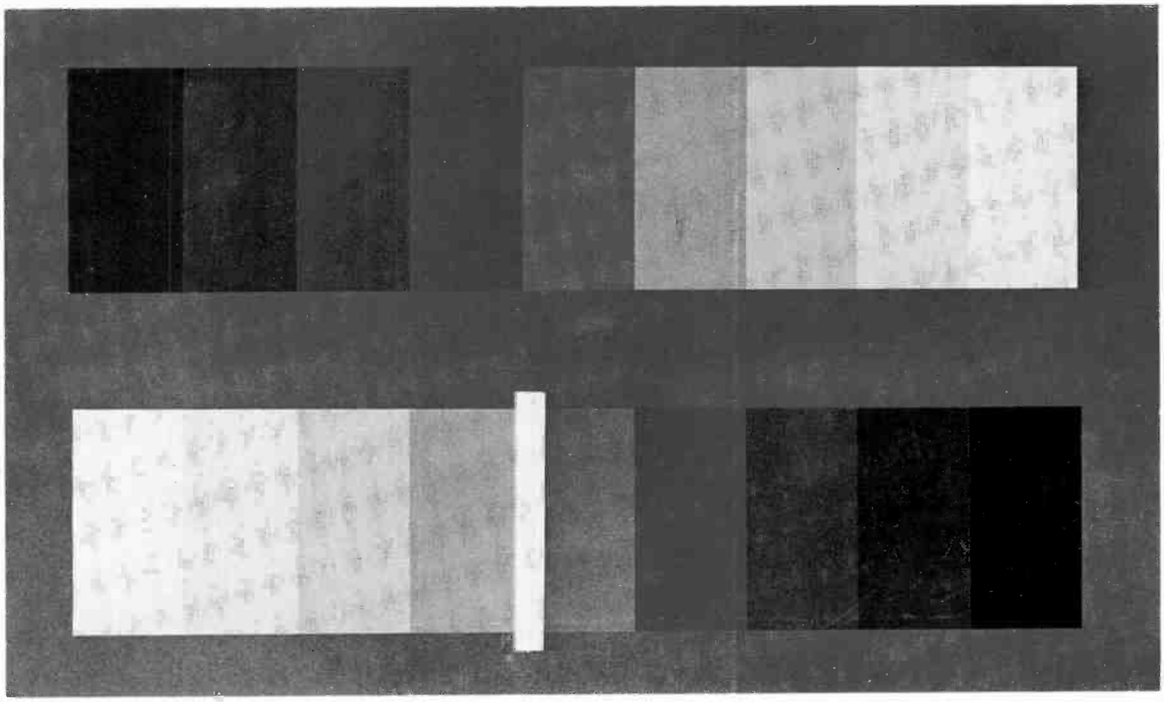

Fig. 1 - A step pattern showing the importance to the eye of the transition between areas of different brightness. The white strip on the bottom step pattern blocks off one of the transitions of the step pattern.

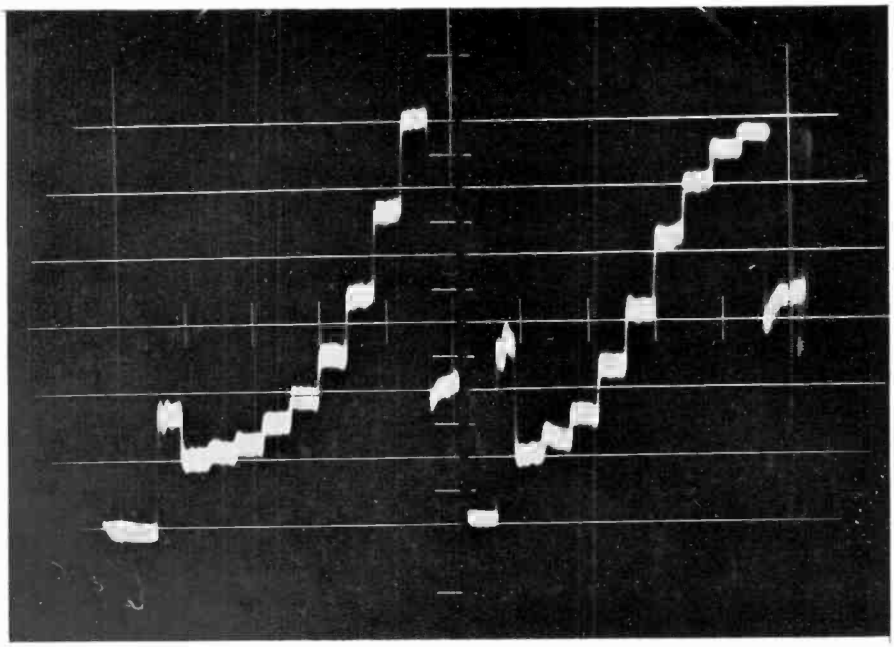

Fig. 2 - 7295A 4-1/2-inch image orthicon operated with a target voltage setup of 3 volts. Left waveform-highlights at knee. Right waveform-highlights 1-1/2 stops above the knee. EIA logarithmic gray scale chart.

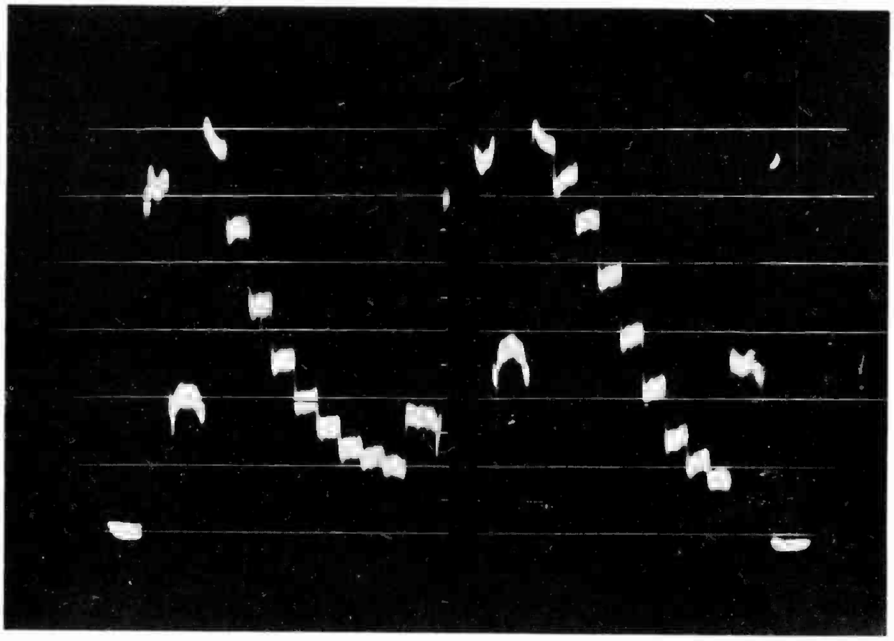

Fig.3 - 7295A 4-1/2-inch image orthicon operated with a target voltage setup of 2 volts. Left waveform-highlights at knee. Right waveform-highlights 1-1/2 stops above the knee. EIA logarithmic gray scale chart.

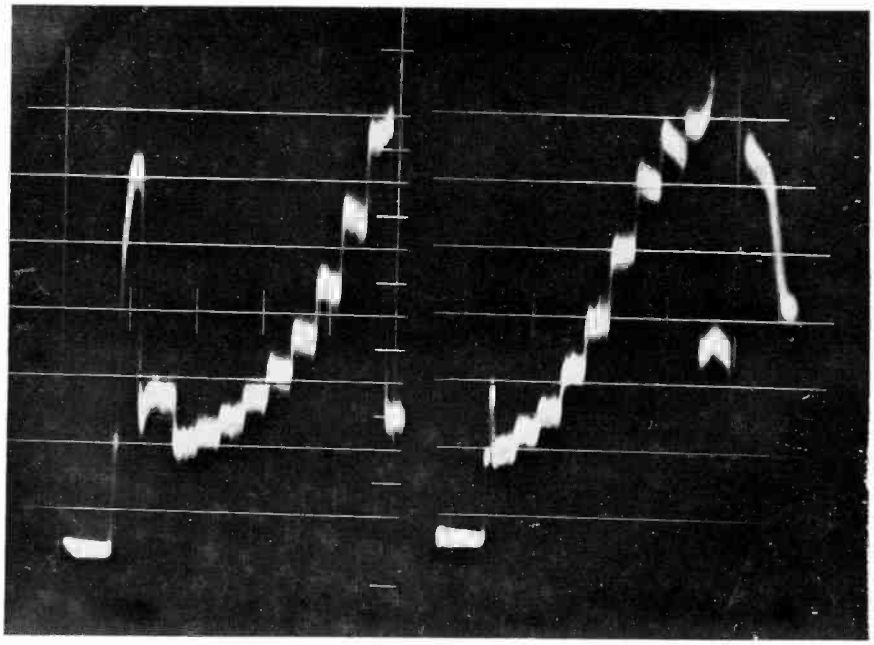

Fig.4 - 5820 3-inch image-orthicon characteristic. Operation is at 2 volts target setup. Left waveform-highlights at knee. Right waveform-highlights 1-1/2 stops above the knee.

Fig. 5 - Direct photography of a very high-contrast subject.

Fig. 6 - Typical 5820 treatment of the subject, operated with the highlights 3 stops above the knee.

Fig. 7 - 7295A picture using a 3-volt target setup and highlights 1 stop above the knee. The dark appearance and lack of "snap" are apparent.

Fig. 8 - 7295A picture using a 3-volt target setup and highlights 3 stops above the knee. Washed-out highlights and harsh effects are readily apparent.

Fig.9 - 7295A picture using a 2 volt target setup, 1-1/2 stops above the knee. Improvement in apparent sharpness and average brightness makes this picture more life like.

Fig.10 - 7295A picture using a 2-volt target setup, highlights 3 stops above the knee. Typical over-exposure characteristics such as black shadows and exaggerated hair highlights are present, but subdued by the 4-1/2 inch tube characteristics.

Fig. 11 7295A picture using a 2-volt target setup, highlights 1-1/2 stops over the knee with 0.8 gamma correction. Tonal value on this is most exact of all setups, and produces the most real picture.

Fig. 12 - Picture of subject with lighter-hair. Conditions are the same as in Fig. 11.

Fig.13 - Same subject as in Fig.12 with typical 5820 operated at 3 stops over the knee.

TV AUTOMATION EXPERIENCE AT KYW-TV

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TV AUTOMATION EXPERIENCE AT KYW-TV

Introduction

Since the first of the year, KYW-TV has been in the process of integrating a newly installed automation system into the station operation. Since my purpose is to discuss this integration process and not the equipment, and since similar equipment can be seen in the Exhibition Hall at the Visual Electronics Booth, I will only briefly mention what the equipment does.

The system operates from information that can be manually punched into a 6-event Storage Display, or punched on to a paper tape from the Storage Display keyboard, or the system can operate from a tape which is a by-product obtained simultaneously when typing the daily program schedule.

The automation equipment then performs all of the video and audio functions of a Master Control, which includes video and audio switching, the operation of projection room equipment, video and audio tape machines, announce booth audio, or a news room microphone and camera.

The equipment reads the tape ahead of all operations by about one full station break and displays this information on a Storage Display Panel, where late changes of any kind can be made. These changes may be in equipment reassignment, or in the timing of the program material.

I have divided my discussion of the process of tying this equipment into the following departments in our station operation:

1. Film Department
2. Traffic Department
3. Continuity Acceptance Department
4. Control Room Operation

Film Department

Our projection room consists of two islands of equipment, each island having a TP-15 Multiplexer, with two 16 mm. projectors working into one Vidicon by the flop of a Multiplexer mirror; and a TP-7 slide projector working directly into the other Vidicon. (Each island also has a Spindle-Sauppe 2x2 slide projector which can be projected into the same Vidicon normally used for the two 16 mm. projectors.)

During video tape sessions, one of the islands is assigned to the video tape crew, and the other island is assigned for air use. Under this mode of operation we normally integrate all feature and commercial film on one reel. This makes the second projector on the air island available for the up-coming integrated reel of film, or when necessary, available for handling a separate commercial reel, that for some reason or another may not have been integrated. During the periods when no video tape sessions are scheduled, then both islands are available for air use and there is no film integration.

One of the periods we have been automating is an hour and a half feature film show entitled "The Early Show". It goes on from 5:00 PM to 6:30 PM. All film and commercials are integrated and the show opens on a series of slides with an announcer and theme under, introducing the movie. After this 20-second introduction, we then go to the feature film for several minutes, which time is predetermined by the Film Department in their editing process. We then make life a little difficult in our transition between one feature segment and the next, by going to a 5-second movie title and theme, then into a commercial, then into a 10-second ID, then into another commercial or a promo, then to another movie title slide and theme with announcer over, and then back into the next segment of the feature film. This now totals anywhere from 3 to 12 events in a 2'20" period between two feature film segments.

Prior to automation it was our practice to run feature films with commercials integrated sequentially in the order that they were to be aired. Whenever a slide, video tape or live announcement was to occur in an integrated feature film period, blank leader having the equivalent time of these other inserts was spliced into the film permitting the projector to continue to "roll through" during the time we switched to these other inserts and at their conclusion back to the film without having to start and stop the integrated film reel.

When we first got into automation, we took advantage of the stop pulses inherent in the system to stop and start the integrated feature film when necessary. It meant that we then had to insert blank leaders equivalent to the stop time and start time of the projectors.

Subsequently, we decided to go back to standard blank leader lengths which were equal to the time of the other inserts required which meant that the Film Department did not have to use two sets of different leader lengths in case we decided to automate or not automate a film program.

We added additional switches at our control point so that we now have an option of allowing the disable pulse from the automation equipment to stop each film if we are running separate reels, or, by a simple flip of the switch, disable the stop pulse from the automation equipment permitting the projectors and/or tape machines to continue to roll while the automation equipment switches in and out of these other inserts.

Some of you may already be using metal foil on your film leaders to stop projectors. In this instance as well as in many other areas, when you get into automation, you may want to incorporate some of the techniques you are currently using or develop new ones for even greater simplicity in handling on-air material.

In discussing the Film Department's problems, they felt that automation had imposed a very severe burden on them. They now had to time an hour and a half long film to make sure it fitted the available time period - hardly an unreasonable request.

It turned out that they were particularly worried about the fact that the final duration of the various segments of the feature film would differ in final integration from the earlier editing times, which had been given to Traffic in order that they could type the schedule, and that therefore, the final time could be at variance from the times punched into the original tape. They were pleased to learn that if they found discrepancies in final timing, they had only to advise the automation control point of the change in timing as they have ample time to make this correction in the automation display - after the event was read out of the tape - but long before it was to go on the air.

The film people use a standard footage counter which has a one-foot circumference divided into 40 frames, with final timing of minutes and seconds appearing on a counter. They found they could expedite their timing and maintain integrals of one second by observing the rotation of the drive wheel indicator. Films are cut to the second for accuracy.

A by-product of the extra attention given to film cutting has been to eliminate the rare occasion where a 60-second film shows up in a 20-second spot or vice versa, which previously had only been detected when it was on the air.

Traffic Department

When a sales order or a program change comes into the house, it is posted on a master board that has slots for all program segments - commercial, public service and promotional spot availabilities from sign-on through sign-off.

Because of the number of alternate week programs and sponsors, we take a two-week old schedule and compare this with the master board for the current day now in preparation. Any changes that may occur in a particular time slot are now written in over the original spot on the schedule being updated.

This updating is usually completed two days prior to the broadcast day involved, at which time the rough schedule is turned over to the TD, who in turn notes any changes that may be necessary in the assignment of equipment. For instance, if there is a substitution of one commercial film for another and they are of the same time duration, no new assignment or change in automation information would be required. However, if a series of slides or video tape was substituted for a film commercial, this type of substitution would require changes in equipment assignment. Then this schedule is proofread and typed one day prior to air time.

One cannot overlook the fact that in some cases a change in one department will adversely affect another. A typical example came up when we decided to print our schedules horizontally instead of vertically on an 8½ x 14 sheet of paper. This was necessary to provide space for the additional columns of automation information. This meant typing a few more characters of automation information as well as more pages. The number of pages increased from 22 to approximately 36, which now means more time is required to run off and collate the number of schedules required. In other words, one of the prices paid for reducing the work load in the control room can result in an increased load and conceivably more people in another department.

This updated schedule is now retyped on a Friden typewriter. This typewriter can be used in one of two ways. The first would be to type and reproduce a master tape which would contain all of the information that is to be reproduced on the daily schedule. Then this master tape can be used two weeks hence to retype an updated schedule and only stopping where necessary to type in the new changes that would apply on the day being updated.

In this process a new updated master tape would be reproduced at the same time, which, when completed, can be run through a tape reader which would extract and reproduce only the automation control information onto a separate control tape for running the equipment. This procedure meant that the master tape, by virtue of having all of the information on it, was yards and yards long and it was somewhat awkward to insert corrected information manually. However, there are other ways of reproducing a schedule which I will touch on in just a few moments.

Meanwhile, we tried a second approach in the use of the Friden typewriter. Assuming now that you have all of the required automation information on the rough draft of your schedule, type the schedule as you would normally, during which process the Friden typewriter automatically turns on the control tape punch only during the "Time On" and "Automation" columns and the punch is again turned off while the descriptive information such as sponsors or program titles, film numbers, or any other extraneous information that has to appear on your schedule, is being typed. This process simultaneously reproduces a control tape that is only approximately six feet long for an hour and a half film show. The tape reader on the Visual automation equipment only reads out the automation information that is typed within the closed brackets. Extraneous time information that has to appear in the Time column of the schedule but not necessary for the automation equipment is now on the tape, but it is ignored by the Visual equipment as it does not appear in closed brackets. The "true time" entry would have been bracketed during the typing process and would automatically start the series of events scheduled to follow such an entry.

Continuity Acceptance Department

Our Continuity Department checks all feature and commercial film, all slides and copy, and video tape commercials for program content. Assuming for the moment that the material has met with the approval of our Continuity Department, accurate timing is the next order of priority.

As mentioned earlier, when all the film has been checked for a particular broadcast day, the Film Department advises our automation control point of any deviation that may arise compared to the timing noted on the schedule, and at that point it is a simple change to make in the Storage Display Board just prior to air time.

We have a number of promotional spots and on occasion commercial spots where they want slides changed on a word cue. With automation, the slides can be changed manually by the operator, or as the copy for the spot is timed out, the actual duration time of each slide in the series is listed in sequence and in turn each slide comes out as a separate event on the Control Tape. This timing has not proved to be an undue burden, and it is next to impossible for anyone to tell that the slides are being changed by automation. However, each series of slides now require more detailed information on the schedule.

Control Room Operation

As you compare one TV station to the next, there are several different configurations of layouts. Some have a master control, a separate film control, and separate studio controls. In other stations a master control area may perform the functions of switching from net to local, and handle local film presentations, with all live programming handled by a separate live studio control crew which is over and above the master control crew.

Briefly, the physical setup of KYW-TV is divided into five major areas. We have a video shading area controlling four Vidicons and five live cameras, a video tape area currently equipped with two video tape machines, a projection room area with the two islands mentioned earlier, a Studio A and its Control Room, and Studio B with its own Control Room, and Announce Booths adjacent to each Control Room.

We use our Studio B Control Room as a combination control point to switch from Net to Local breaks, and back to Net. They run local film or video tape shows on the air. This same crew also handles several local live shows directly to the air throughout the broadcast day. As a matter of fact, this same Studio B control point also performs a limited amount of video taping.

Studio A and its Control Room is used for the majority of our video taping activity and is manned by a separate crew. We also air a local live variety show from Studio A handled by the Studio A crew from 1:00 PM to 2:30 PM, Monday through Friday, with Mike Douglas as the host.

I am sure it is quite obvious from the above that our mode of operation differs from the way many of you run your stations.

Normally, Studio B is manned with a TD who starts projectors or tape machines, changes slides, and performs other video camera switching functions; an Audio man and a Program

Director, in the case of film shows and during some station break periods, an AD in place of the Director.

Currently, during the periods that we are now running on automation, the audio work and the direction formerly done by an AD is now performed by automation. For all practical purposes we have a one-man Master Control room run by a Technical Director.

We have automated Net breaks during different times of the day - "The Early Show" described previously, and again automated "Program PM" and our "Late Show." These shows run from 11:15 PM to approximately 2:30 AM, Sign Off.

During automated periods, the TD's main responsibility is to insert the Control Tape in the tape reader, set the automation in operation, and monitor the events as they appear in the 6-event Display. This Display normally includes the next complete break 10 to 15 minutes before its air time. Even with an increased number of events in a station break, there is always a one-minute commercial or a promo in the break during which time he can change any succeeding events of the particular break in question. If there is a last minute change dictated by equipment failure, late sales orders, or last minute program changes necessitating a major reassignment of events in a break, the TD can now punch a new segment of tape for the particular break in question, insert it in a second reader and set a timer to cause a switchover to the corrected tape. Then at the end of this corrected sequence, go back to the main reader.

Because of the delays that were encountered in our Traffic Department in trying to get exact durations and equipment assignments typed on the schedule, the fact became very obvious that if the TD is provided accurate updated information at some reasonable time prior to air time, he has ample time to feed the information into the 6-event Storage Display Board at his leisure prior to a station break, or in the case of the hour and a half long programs that we have automated, he has more than ample time to prepare and check out a Control Tape with all of the facts involved just prior to its airing. As a matter of fact, a TD can punch a Control Tape for an hour and a half film show with all its various inserts and check this Control Tape in his Display Board in approximately five minutes.

Automation has not "locked us in" to one rigid system of operation for any particular time of the day.

Automation has now changed the TD area of responsibility in that he is no longer required to watch the schedule and drop everything to become a "button pusher" every few minutes. He is relieved of the last second pressures of switching requirements to devote his full time to the over-all surveilance of our end product. One further advantage is the alleviation of errors attributed to "lunch relief" operators that can happen on a rare occasion. The Audio man and the AD are reassigned to other more pressing assignments such as more video taping or maintenance.

Planning For The Future

At the outset, we installed the automation on a plug-in basis in our Studio B Control Room area, not knowing how much need there would be to insert special effects or mix audio during the periods which we were going to automate. Actually, it has turned out that the demands for this type of activity have been minimal. At a later date we propose to consolidate our automation control point in the Video area which will free Studio B and its Control Room for increased video tape activity. This will further extend the functions of the automation TD to cover not only video and audio switching, but video and audio level control. Levels are already controlled to a large extent by various forms of video and audio AGC units.

As I have just stated, we found it more expedient to have the TD's punch the Control Tape in the areas that we are currently automating. However, in analyzing the changes in updating a Traffic schedule two weeks hence, we find that only 35% of the total entries have to be changed, so it becomes obvious that much of the material that goes into a corrected TV schedule is being handwritten repetitively, including the retyping of 65% of the information repetitively, on a daily basis.

It is apparent from this analysis that our sales order should be entered on to a punched card and insert these in a hopper to feed this information into the printing device to reproduce a schedule and also use a hopper to feed these cards directly into the Visual automation equipment.

Further advantages can be derived from this process by coding additional information on the original sales order to derive the breakdown of the requirements of a composite week, including posting and automatic billing, from these same punched cards. This also provides a greater degree of flexibility to accommodate last minute sales orders or program changes by a substitution of the cards stacked in a hopper.

Conclusions

The advent of automation can shift many burdens around from one department to the next. In some cases the problem encountered may be very difficult to resolve, such as the snag we hit in reproducing a Control Tape simultaneously with the typing of the daily schedule.

Automation has not permitted us to make a reduction in our manpower requirements primarily due to the fact that the same film control crew is also required for the several live programs that they handle that are interspersed throughout the broadcast day. It has minimized our lunch relief problems and provided more maintenance man hours.

In essence, automation has provided an increased degree of efficiency coupled with a more accurate professional presentation of "on air" material. It has been suggested that automation would stereotype the broadcaster, but it now permits him to devote more of his time to creating local live productions.

So far, the project looks good and we are continuing to investigate further integration and automation of our Sales, Traffic and Billing Departments. New additions to the equipment are well underway to operate from punched cards, which can be easily converted to feed our existing equipment if their use is deemed desirable.

Techniques have now been designed to permit the automation to provide instructions for laps and fades, and at least two manufacturers have switchers underway to handle electronic laps and fade. Frankly, we find our commercials and other program material has enough laps and fades in it that the present automated "transitions" are not objectionable.

Every technician has a streak of "creativity" that is not utilized to its utmost, particularly performing routine button pushing for station breaks and film shows. For all practical purposes these are strictly manual operations. Being freed from these more tedious button pushing requirements should permit him to devote more time to use his creative abilities and ingenuity in meeting new demands to improve the technical standards of our medium.

From our experience to date in what we see coming along, I feel we are on the right track and none too soon. I know many of you have already contributed to the pioneering feat of automating broadcasting; it is now destined to catch up with the many other industries that have long since been automated.

INTERLEAVED SOUND TRANSMISSION WITHIN THE TELEVISION PICTURE

J L Hathaway
National Broadcasting Company
New York, N.Y.

Summary

A system is described for combining sound d picture signals and transmitting them over a ngle video circuit in such a manner as to prode an emergency sound service for use during ilures of the regular television audio facilies. Picture and sound portions of network ograms are ordinarily carried by inter-city rcuits which differ in apparatus and routings. though each has been subject to occasional rvice interruptions, simultaneous failures have en highly unusual. This Interleaved Sound stem creates no degradation of picture quality, ds no interference components to the picture gnal, and provides recovered sound of adequate ality.

The Problem

Television broadcasting networks are occa- .onally troubled by failures of interconnecting ımmon carrier circuits, even though advanced, liable, well maintained equipment is used. .though television sound failures attributable) the common carrier have become less frequent ı recent years, a tabulation for 1960 on NBC ırcuits shows many hundred interruptions lasting ›nger than 30 seconds. As an example of one, ısulting from a switching error, CBS audio was uted on Bob Hope's video over NBC; thereby ıterrupting several minutes of sound and pro- .ding front page newspaper coverage. Sometimes ; seems the public is so engrossed with pictures ıat sound gets little consideration until there ı a break in its continuity; then the lack of ›und becomes of primary importance.

Picture and sound circuits are normally ırried over inter-city facilities which are dif- ›rent in types of apparatus and in routings. ıe major difference is that video circuits are ıe-way only, whereas the audio is reversible by ›ans of a series of relays operating in tandem ; the many repeaters along the route. Actuation ' these relays is sometimes adversely affected r spurious voltages developing along one or more ' the many lengths. This and many other factors ıve caused television sound outages, but it is ›teworthy that these have seldom occurred .multaneously with picture circuit failures.

Early Considerations

The need for economical emergency sound ıcilities has long been recognized by broadcasting networks, in fulfilling their mission of public service. Several years ago consideration was given to development of a system similar to that employed in microwave relaying, wherein a frequency modulated channel is multiplexed above the video frequencies. This seemed expedient and might have provided a high quality circuit if the video spectrum had been slightly curtailed. However, it would not have functioned on circuits which did not transmit the multiplexed channel properly. The decision to avoid using the extremely high end of the video spectrum proved wise, in view of the fact that for reasons of economy broadcasters are now using somewhat narrower inter-city facilities.

Interleaving

A system of Interleaved Sound has now been developed to a state of practical utility, wherein video and emergency audio are transmitted over a single video circuit. In this system, the sound is interleaved within the picture components like a sheet of paper between two of the many pages of a book, while the book remains intact. This means that the band requirement is no greater than for video alone. It also means no added hardships are imposed in handling the video and the audio.

The system of interleaving sound is possible because of the nature of television signals. Many years ago it was found, experimentally and mathematically, that television scanning of a picture produces concentrations (or "clumps" of energy) distributed throughout the video spectrum at harmonics of the horizontal line scanning frequency, each having sideband components at multiples of the field scanning frequency. Between these clumps there is little video energy and it is into one of these "gaps" that sound is inserted. A few of the energy clumps are represented in Figure 1, together with audio signals interleaved between two selected clumps — in this instance the 113th and the 114th harmonics of line scanning frequency. The gap is rather narrow, especially for pictures including considerable high-contrast finely detailed material; so for this reason, single-sideband, suppressed-carrier transmission is used for the sound. Any other gap in the same general portion of the spectrum could have been chosen and used just as well as that between the 113th and 114th harmonics. Tests showed, however, that video interference between the clumps increases at lower frequencies. In the direction of higher frequencies the interference would have been much lower, if the gaps were not occupied by chrominance components during the transmission of color.

Transmitter & Receiver

A single-sideband sound generator and a sound covery unit were constructed in 1958 for evalting the principal of interleaved sound. Figure diagrams these units in block form and is genally self-explanatory. Both the transmitter d receiver are "filter" types, employing unsymtrical crystal filters to pass only the upper deband and to give sharp attenuation of freencies near and below the suppressed carrier equency. The filters have identical charactertics, with measured frequency response as shown Figure 3.

Pass range of the crystal filters is cenred between the 113th and 114th harmonics of e <u>average</u> frequency of horizontal scanning. is centering results in minimum interference om video into the audio and vice versa. Monorome television horizontal frequency in the USA verages 15,750 cps, with slight variations caused changes of the 60 cps power line frequency ich is generally used to control the synchronzing generators. Color television employs a orizontal frequency 0.1% lower. Center freency for the audio energy is determined by ltiplying one half the average horizontal freency by an odd integer. Sound is placed etween the harmonics previously mentioned when is integer is 227, thus:

$$f = \frac{1}{2}\,(15{,}750 - 0.05\%) \times 227 = 1{,}786{,}731 \text{ cps.}$$

he carrier should be located approximately 1000 ps lower in frequency, or at 1,785,700 cps.

Temperature regulated quartz crystal oscilators are used in the transmitter and receiver, nd a means of readily checking frequency of the eceiver against the transmitter is provided. hese frequencies must match within about 4 cps, s the recovered sound will otherwise be offset n frequency enough to implant a slightly unatural characteristic to certain voices and ther program content. Operationally, the frequency check and adjustment may be accomplished t any time when the emergency circuit is not in se. A switch at the transmitter applied 120 cps one modulation which is derived from the 60 cps ower frequency. If, at the distant recovery nit, the audio output exceeds the limits 120 ± cps, the local oscillator should be trimmed. xtreme accuracy is possible in this checking, y connecting an oscilloscope to the receiver utput and sweeping the trace with the local 60 ps power frequency. In metropolitan areas, ower frequency is generally maintained within .1 cps. Under typical operating conditions, here Interleaved Sound and all surrounding pparatus are turned on 24 hours daily, stability f the oscillators is such as to require a frequency check on a weekly basis. The crystal ilters and all other components are sufficiently table to make balancing and gain readjustments nnecessary over months of continuous operation.

Preliminary Results

Laboratory testing of the system was first conducted by adding the single side-band sound to the picture signal and recovering the sound components without any long interconnecting circuit. Results were good enough to warrant trials over actual video circuits, so a test was conducted from Radio City to Brooklyn and return. This test also was very satisfactory, so next a circuit of over 2000 miles from New York to St Louis to Chicago and return was tried; again with equally good results. Finally, as a check on transmission over extreme distances, tests were made on a coast to coast and return common-carrier of more than 7000 miles total. Here again results were good; there was no significant degradation of sound as compared to the original laboratory bench tests conducted without any inter-city circuitry. Furthermore, the video signals suffered only the normal degradation associated with such long-distance transmission.

Control of the level of the Interleaved Sound signals is extremely important, since an excessive level creates interference patterns on the picture while insufficient level causes objectionable buzzing in the recovered sound. For the tests over various long distance circuits, the normal level of sound transmission produced peak to peak voltage measuring one percent of the peak to peak television signal voltage. Figure 4 depicts a video waveform with and without the added sound signals. Under this condition of transmission, no trace of sound interference could be seen on the picture, even on closeup viewing of large high quality monitors. At this transmission level the recovered sound was highly intelligible and adequate for use during short periods of interruption of the regular audio circuit. For prolonged listening, however, an improved signal-to-noise ratio was highly desirable; so the plan was to have the receiving end of the circuit initiate a telephone call to the transmitting end as soon as possible after an interruption occurred and the emergency circuit had been placed in use. The call would bring about a fourfold increase of transmitted sound level and receiver sensitivity would be dropped 4 to 1. This resulted in a recovered sound signal-to-noise ratio improvement of 12 db. Although this caused 4% modulation of the television signal by the sound, interference into the reproduced picture was insignificant and unnoticeable in ordinary television viewing.

A 30 day test was conducted, with FCC authorization, in the Fall of 1960 from New York, with a sound recovery unit located at Washington, DC. Sound signals were added to all programs originating in or passing through the Radio City, New York control center. Normally 1% level prevailed but on many occasions the 4% level was used to simulate emergency conditions. AT&T Long Lines personnel as well as those of all NBC affiliated stations were alerted prior to the test; however, some days after its inauguration, reports indicated that many had not only failed to see any sign of interference to the pictures, but were wondering why the test had not started as scheduled! During the entire month there was not one comment from the public which could in any way relate to interference from the added sound signal; furthermore, the network affiliates reported no interference. A demonstration was given to FCC members and staff on the final day of testing.

Improved System

Success of the 1960 test lead to the trial of another development. This has proven well worthwhile and results in three major advantage over the earlier system:

1) The signal-to-noise ratio of the received signal is always satisfactory for immediate and prolonged emergency use and the level need not be increased above the normal 1% value.

2) Satisfactory signal-to-noise ratio is obtained at lower sound transmission level, so there is never the slightest vestige of interference to the picture.

3) Elimination of the level change required when a sound interruption occurs at a distant city simplified operation as compared to the two-level system.

The only change apparatus-wise for realizing these advantages is in the addition of a special filter to clear the channel for the subsequent injection of Interleaved Sound signals. A double-notch filter eliminates most of the video components which would ordinarly occur at relatively low levels between two adjacent clumps of video energy. In the early system, practically all of the adverse noise in the recovered sound was created by video crossover; therefore a reduction of these crossover components reduces the noise to a degree dependent on the filter's attenuation throughout the channel. A block diagram of the over-all transmitting and receiving system for video, regular audio, and emergency audio is given in Figure 5.

Notch Filter

A suitable filter must be sufficiently selective to reject the desired band of frequencies without material attenuation or phase shift at the frequencies of the adjacent video clumps. These criteria are met in the present filter by using LC-tuned circuits arranged to cancel video at two frequencies. The over-all filter, with isolation amplifier for over-all unity gain in a 75 ohm circuit, is shown in block form in Figure 6. The LC-tuned circuits have a Q of around 150 at the tuned frequency of approximately 1.78 mc. Each of these is provided with an amplitude and phase control (as well as tuning control) so that after passing through a cathode follower, cancellation of the video signal may be achieved at the resonant frequency. The two LC circuits are slightly staggered in tuning to give the response shown in Figure 7. This curve is plotted with greatly expanded scale of frequencies around the sound channel in Figure 8. Although the unit does not represent the ultimate in performance for this application, it has proven relatively stable and easily controlled. Furthermore, it provides a subjective improvement of at least 12 db in the recovered sound signal-to-noise. A preferred filter design would utilize a number of crystals which would give four or more rejection frequencies. Such a filter should cover a wider band of frequencies having at least 20 db of attenuation but a narrower band having no significant attenuation or phase shift. This would result in improved signal-to-noise ratio of the recovered sound without introduction of video "ringing."

Performance & Status

The over-all system described and presently in use as an emergency sound circuit covers the audio frequency band from 100 cps through 4300 cps, flat within ± 2 db. Harmonic distortion is below 3% RMS. Signal-to-noise of the recovered sound is a changing factor, depending on the nature of the video. In general, measured RMS noise is between 27 db and 45 db below RMS program; average video produces a figure of approximately 36 db. This is substantially the same on coast-to-coast circuits as on very short circuits.

Interleaved Sound transmitted at the specified level and radiated by a broadcaster produces no detectable change or deterioration of received picture quality and no co-channel or adjacent channel interference. Furthermore, the level of transmission is so low that the sound signal which is added to video is far below the system noise limit specified by the FCC. Thus, the broadcaster's service to the public is never deteriorated by the existence of emergency sound, but whenever there is a failure of the regular audio circuit, this system makes all of the difference between having and not having sound.

An agreement has been negotiated giving the common carrier ownership of the experimental equipment, and the network is now operating this over the New York to Hollywood circuit. The operation has been authorized by the FCC for a period of one year. Presently the American Telephone & Telegraph Company is testing other systems of transmitting sound together with video over a single circuit. They hope to evaluate the various possible systems and to carry to completion the development of whichever proves the most practical.

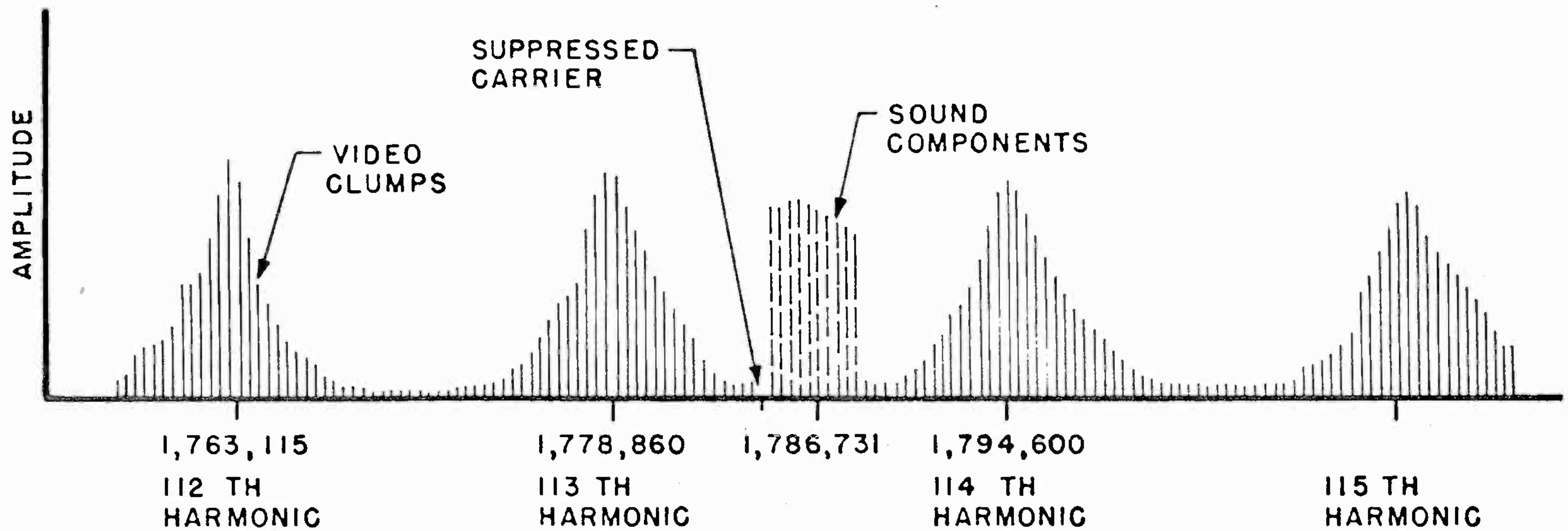
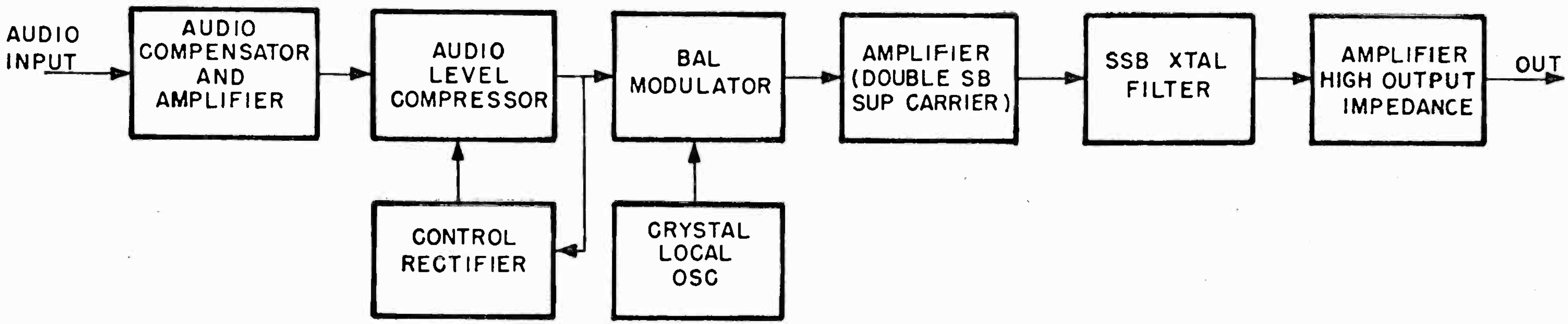
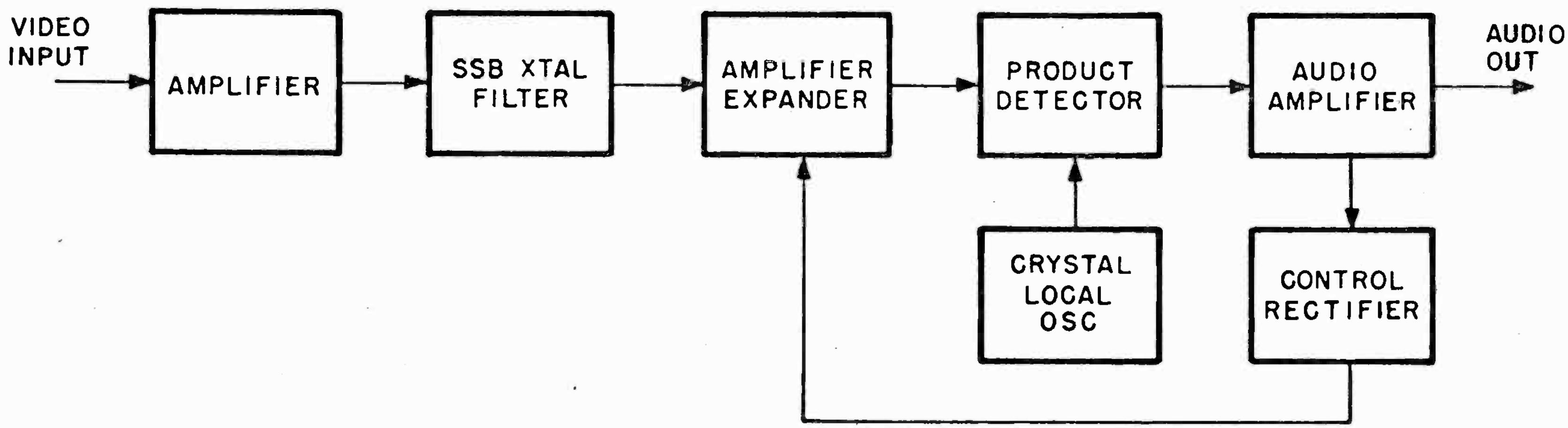


FIG. 1

VIDEO ENERGY CLUMPS
AND INTERLEAVED SOUND



EMERGENCY SOUND GENERATOR



EMERGENCY SOUND RECEIVER

FIG. 2

SINGLE-SIDE BAND BLOCK DIAGRAM

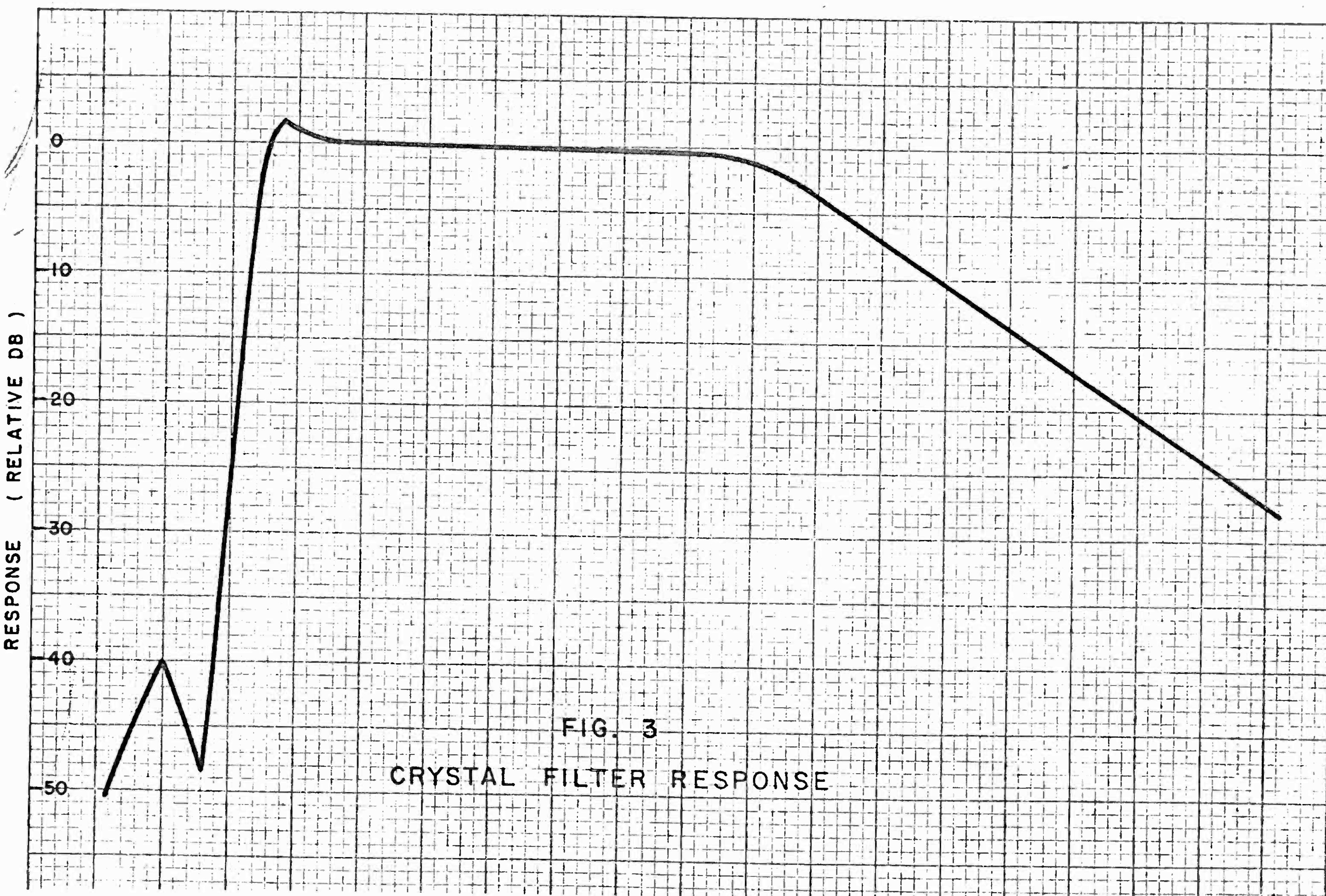


FIG. 3

CRYSTAL FILTER RESPONSE

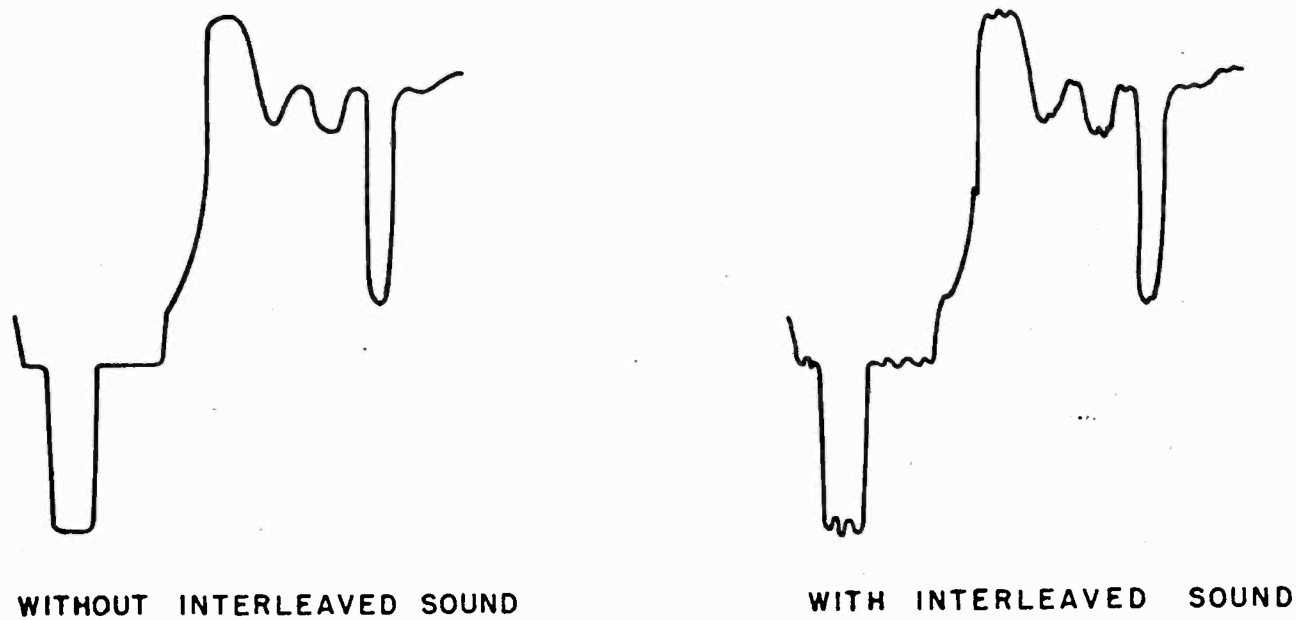


FIG. 4
VIDEO WAVE FORMS

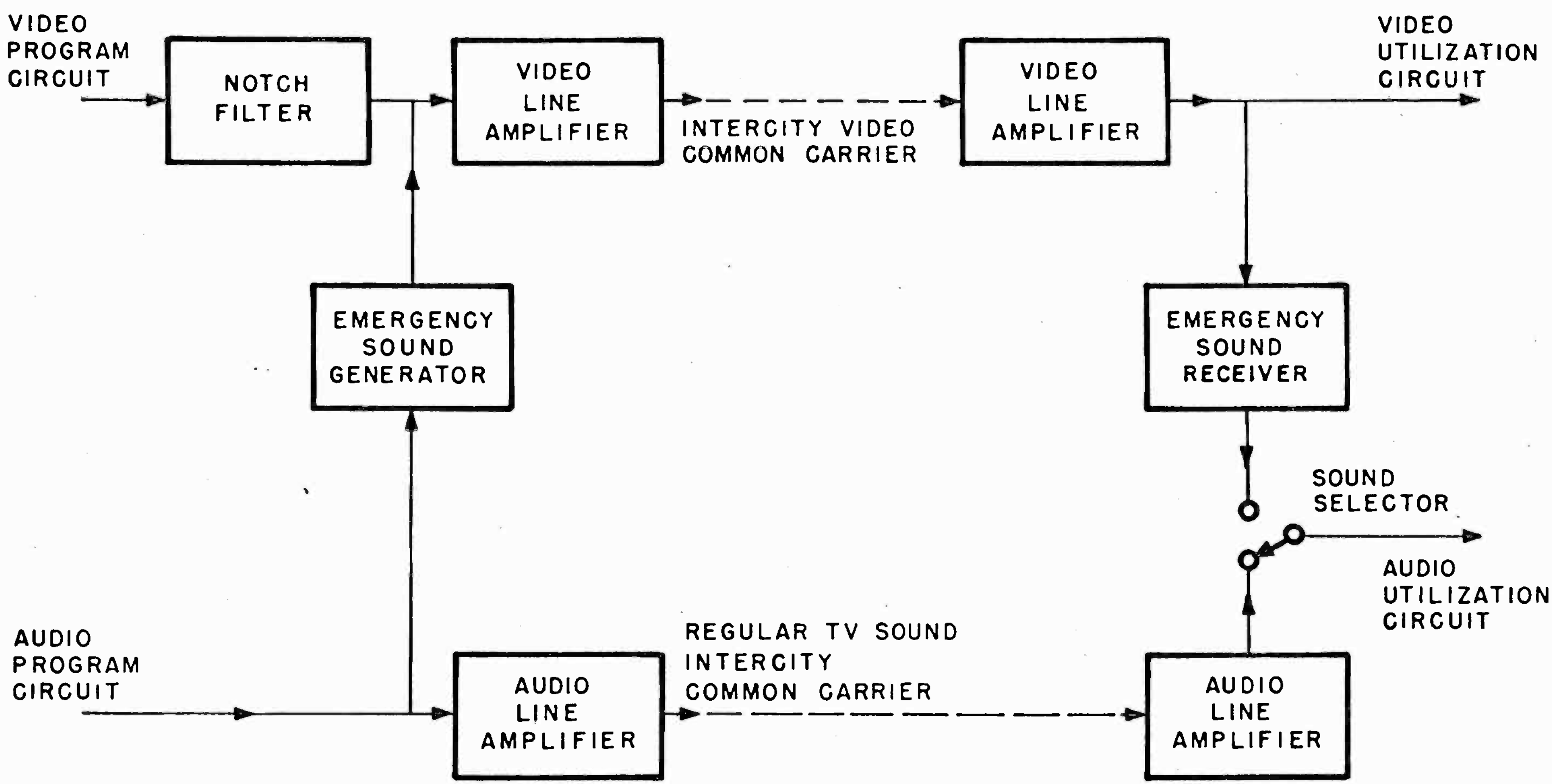


FIG. 5

BLOCK DIAGRAM
INTERLEAVED SOUND

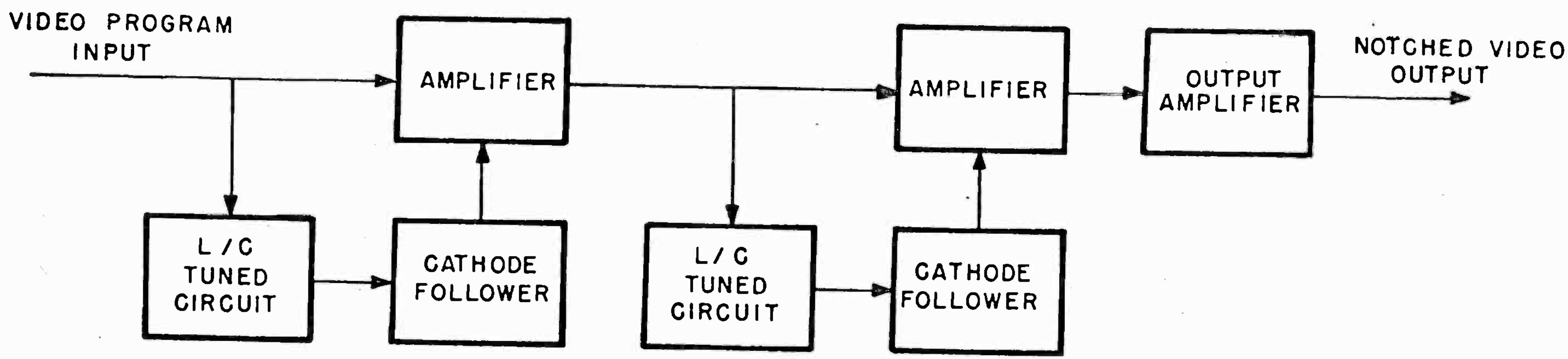


FIG. 6

UNITY GAIN NOTCH FILTER

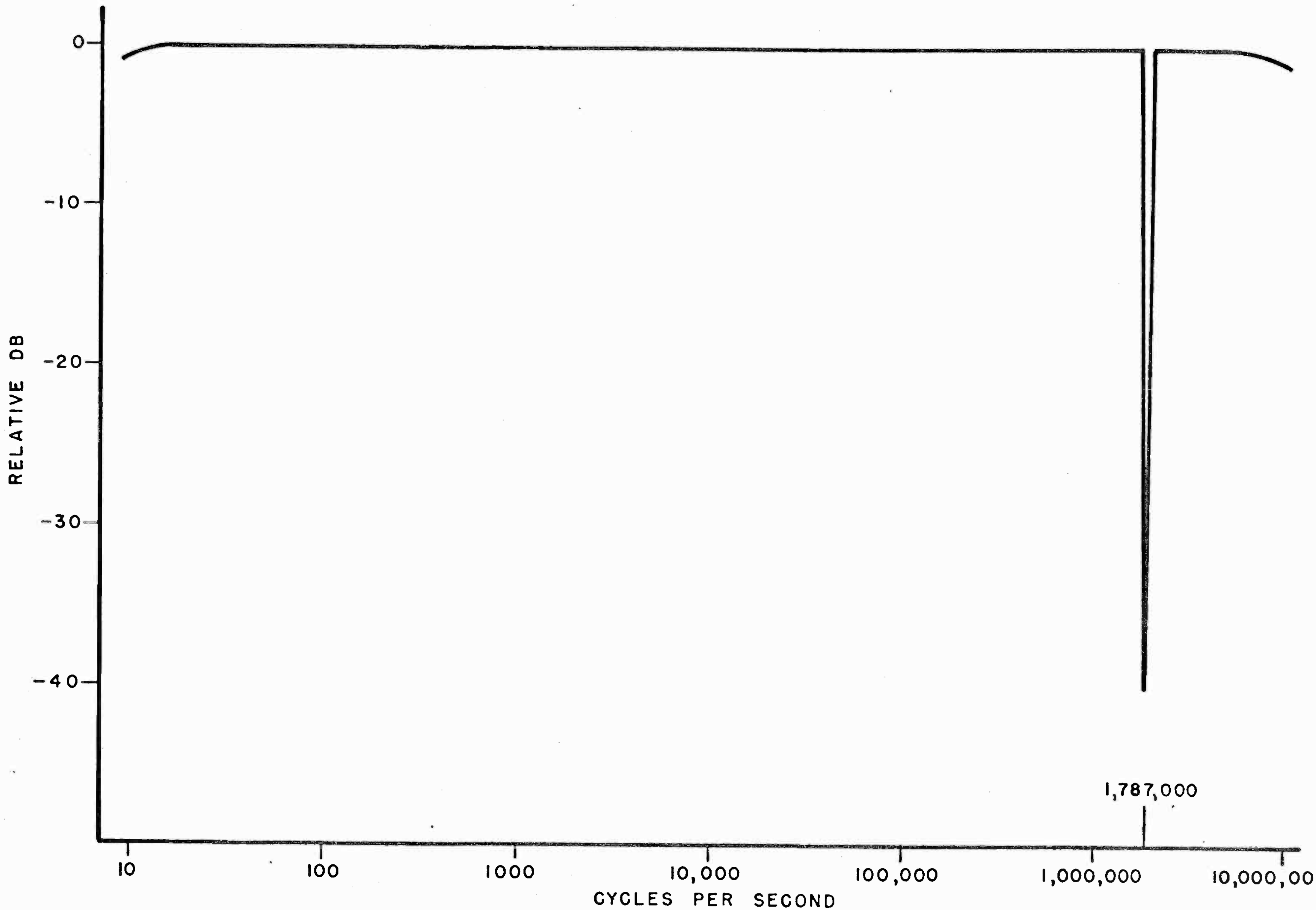

RELATIVE DB
0
-10
-20
-30
-40
1,787,000
10
100
1000
10,000
100,000
1,000,000
10,000,000
CYCLES PER SECOND

FIG. 7

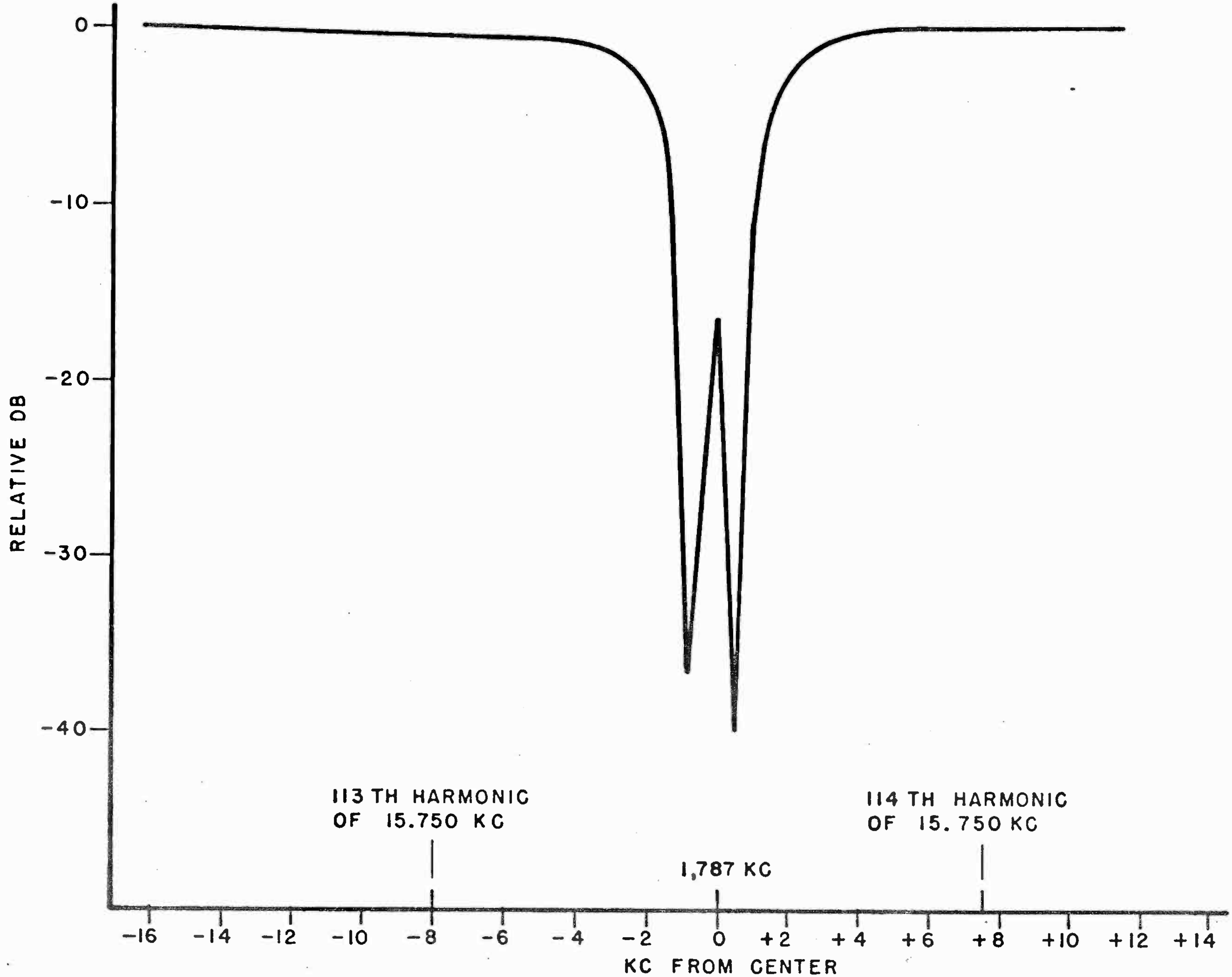


FIG. 8

INTERLEAVED SOUND NOTCH FILTER

NEW CONCEPTS IN THE EVALUATION OF TELEVISION LENSES

By Dr. Frank G. Back

(Paper presented at National Association of Broadcasters Convention, Chicago, Illinois, April 3, 1962)

Dr. Frank G. Back, ME, ScD., has long been prominent in the fields of television and photographic optics, and has made major contributions to the progress of television, motion picture and still photography through the design of varifocal lenses and other optical equipment. He is the inventor of the Zoomar Lens. This is the oldest and best known zoom lens, and is universally used in television, motion pictures, and still photography.

Dr. Back holds over fifty patents in the United States and abroad, marking his accomplishments in the optical field.

He is the author of numerous scientific articles which have appeared in the Journal of the Society of Motion Picture Engineers; the Journal of the Optical Society of America; Review of Scientific Instruments; Television Magazine; the Broadcaster; and many others.

For his achievements in television and in photographic optics, Dr. Back received the Gold Medal Award of the Television Broadcasting Association in 1947; and the Gold Medal Award of the Photographic Society in Vienna, Austria in 1960.

He is a Fellow of the Photographic Society of America; the Society of Motion Picture and Television Engineers; Society of Photographic Scientists and Engineers; and the Royal Photographic Society of Great Britain.

Dr. Back is in charge of Research and Development at Zoomar, Inc.

ABSTRACT: Methods of image evaluation in terms of resolving power only, are unsatisfactory and misleading. Lenses should be tested with their ultimate application in mind. Methods for conducting reliable tests on television lenses will be discussed.

Up to now, resolving power seemed to be the only yardstick used to evaluate lens performance. This is done with a test target, or test chart, showing resolution patterns indicating the resolving power in lines per millimeter or TV lines per frame height.

From experience, we know that this method of image evaluation has proven unsatisfactory because lenses showing very good resolving power are disillusioning in actual performance use, and vice versa. It has been proven that resolving power, though a desirable property of a lens, cannot be the only gauge of evaluation. In especial, when full frame covering test charts are used, giving the resolving power in the center, on the edges, and on the corners simultaneously, the results in predicting lens performance are more than questionable.

There are several reasons for this. First of all, there are only very few instances where the subject to be photographed or televised, lies, as in the test chart, in one plane only. We are, therefore, combining resolution and field flatness unnecessarily in one test. Field flatness is a very rare necessity in photographic applications, and very unimportant in television work where practically every object exists in three dimensions. As long as the field is not excessively curved, field flatness as an indicator of quality is a very unimportant requirement in a television lens.

Furthermore, a lens can have an extremely high target resolution, but the picture may appear washed out and lacking in crispness. Exhaustive tests have proven that detail contrast has much more bearing on final picture quality than resolution.

Actually, we have to deal with two types of contrast: transfer contrast, and color contrast.

Transfer contrast in a lens is the degree of its capability to make a sharp transition on a division line from pure white to pure black. Transfer contrast can, for all practical purposes, be measured with the electronic testing method devised by Otto Schade, and gives a better indication of lens behavior performance on actual television work than resolution tests with test charts. This test can give numerical evalution figures matching reality closely, provided the lens was focused for each part of the field to eliminate any deviation caused by field curvature.

Color contrast is influenced by four conditions: (1) color overcast through internal reflections; (2) color absorption by glass and coating; (3) longitudinal color; and (4) lateral color.

Color overcast is actually a monochromatic component of the transfer contrast and should, therefore, be considered as part of it.

Color absorption by glass and coating can be used advantageously like a filter, and is therefore not necessarily a disadvantage, as shown later.

Longitudinal color aberration of a lens manifests itself as a color change from bluish-black to reddish-black in small dark picture areas while going through focus. It does not affect TV picture quality, especially in view of the low blue sensitivity of the average orthicon.

Lateral color, however, (which in simple words means different picture sizes for different colors though in sharp focus), results in color fringes; very objectionable in any color photography, and very objectionable in black and white photography as well as in black and white television. The edge portions of the frame will show color fringes in a color photograph and will look fuzzy and unsharp in any black and white picture.

In color TV, however, conditions are altogether different. Our TV color system has some unique requirements, and from the aspect of lenses used for TV cameras, very much different from monochrome. Since the entire light bundle is split up into the three primary colors, and each color is fed to a separate orthicon tube, it is no longer necessary to have the focal plane for red, green, and blue at the same plane. It is not even necessary to have the three color component pictures exactly identical in size, as is required in black and white (provided all lenses on the same turret, or all positions on a zoom lens, show the same amount of color aberration).

Here we reach the strange conclusion that a lens used on a color television camera does not have to be color-corrected for lateral and longitudinal color; and this gives us a wonderful opportunity to concentrate on the elimination or reduction of other optical aberrations, provided that this special lens is intended for **color TV** only.

There is, however, a requirement for color TV lenses which exists neither for monochrome TV nor for photography. As we know, the orthicon with the lowest sensitivity is always the blue one, and the level of illumination in color TV is therefore established by the blue orthicon. The red and the green beams have to be dimmed by neutral density filters to get proper color balance.

It is, therefore, highly desirable to use optics with an extremely high blue transmission, even if the red and green transmission should be lower, because these two color intensities have to be reduced anyway. Since multiple element lenses, especially zoom lenses, have a great number of glass-air surfaces, the high blue transmission can be achieved very easily by coating the lenses yellowish instead of bluish-purple. Lenses coated in that manner will definitely give an increased blue transmission, and can therefore be used either on color TV cameras with a lower light level or with their diaphragm farther closed down, thus giving greater depth of field.

A lens made with increased blue transmission will give superior results on color TV only, and does not benefit the

TABLE OF DESIRED LENS PROPERTIES FOR VARIOUS APPLICATIONS

LENS PROPERTIES: / APPLICATION:	Photographic Lenses: Mapping	Reproduction	Commercial Photography	Architectural Photography	Medical Photography	Motion Picture - Studio	Motion Picture - Travel	Aerial Photography	Amateur Photography	Projection Lenses	TV Lenses: Monochrome TV	Color TV	4-1/2 inch - Orthicon	ITV - Outdoor - Day	ITV - Outdoor - Night	ITV - Indoor
Resolving Power	H	H	D	D	D	D	D	H	D	D	D	D	D	D	D	D
Transfer Contrast	D	D	D	D	U	D	D	H	D	D	D	D	H	D	D	D
Field Flatness	H	H	U	D	U	U	D	H	U	H	U	U	U	U	D	U
Distortion-Free	H	H	D	H	U	D	D	D	U	D	U	U	U	U	U	U
Longitudinal Color Correction	U	H	U	U	U	U	U	U	U	U	U	U	U	U	U	U
Lateral Color Correction	H	H	D	D	U	H	D	H	H	D	D	U	H	D	D	D
High Transmission	U	U	U	U	H	H	D	H	D	H	D	D	D	U	H	H
Increased Blue Transmission	U	U	U	U	U	U	U	U	U	U	U	D	U	U	U	U
Compactness	U	U	U	U	D	D	D	U	D	U	D	D	D	D	D	D
Ease of Interchange	U	D	H	H	D	H	H	U	D	D	D	D	D	D	D	D
Operation	M	M	M	M	M	M	M	R	M	M	M	M	M	R	R	R
Low Cost	U	U	U	U	D	U	U	U	H	D	U	U	U	D	D	D

H . . . Highly Important
D . . . Desirable
U . . . Unimportant
M . . . Manual
R . . . Remote

monochrome camera. The reduced red-green transmission, which is a consequence of the increased blue, will, in fact, necessitate a larger diaphragm opening on black and white than if the lens was coated bluish-purple.

There is no such thing as a universally perfect lens, and the optical designer has to make more compromising decisions than any other technical designer. Lenses which are excellent for one application might be completely inadequate for others.

The foregoing Table shows most possible lens properties and shortcomings versus photographic and television applications in a self-explanatory manner. We can see immediately that a lens for a special application has to have certain properties, and since other requirements are unnecessary, all effort can be made to concentrate on its necessary qualities.

Looking at the foregoing Table, we can see that the standard test charts used every day for lens evaluation are inadequate and misleading. To check resolving power in the center, the edge, and the corner by counting the resolved lines, takes, as mentioned before, the field flatness into consideration also. Though this can be easily eliminated by focusing separately for center, edge, and corner, all other important lens properties can not be revealed by our standard chart.

The Otto Schade method, developed especially for testing TV lenses and equipment, will give numerical figures for transfer contrast, which is very important for TV applications. However, the method needs special laboratory setups, and does not answer all requirement questions.

Scientifically accurate numerical tests can be conducted only with elaborate testing equipment, which most of the time also requires highly skilled operators.

A comparatively simple method (though giving only limited numerical figures) is lens testing by projection. Here we go the other way around, using test targets at the focal plane and projecting them on a screen. By slowly moving through focus, all of the important lens deficiencies and aberrations can be easily observed; and predictions for future lens performance to any application can be made with a great amount of certainty by even semi-skilled investigators.

It is hard enough to make conclusive tests for single-purpose lenses and to reach a verdict about their quality for a set purpose. For zoom lenses it is still more complicated. A zoom lens should be tested for a great number of settings because the aberrations change from position to position.

Here, again, the projection test can be conducted in a very simple and efficient manner, revealing shortcomings or deficiencies within minutes, where bench tests would take hours to conduct. A test projector has to be designed in such a way as to eliminate any cut-offs of coma bundles, and a variety of targets can be used to make the tests conclusive. Projection testing eliminates all errors caused by the electronic chain or photographic processing.

* *

SEVEN YEARS OF SIGNIFICANT

COLOR TELEVISION RECEIVER PROGRESS

* *

CLYDE HOYT, Manager, TV Receiver Engineering

Home Instruments Division

Radio Corporation of America

to be presented April 3, 1962
11:30 - 12:00 noon
CONRAD HILTON HOTEL, CHICAGO

at

<u>16th National Association of Broadcasters</u>

<u>Broadcast Engineering Conference</u>

THE COLOR TELEVISION RECEIVER OF TODAY

-

A PHILOSOPHY OF DESIGN AND PERFORMANCE

During the last seven years the color TV receiver in the home environment has been developed and refined. Today it is an intricate device that is easy to adjust, stable and approaches closely a high quality black and white receiver in service requirements. Brightness is now approximately two times greater than initially; contrast is considerably higher and resolution is appreciably improved.

The consumer viewer molds the philosophy that determines the color TV receiver's performance and features. Of paramount importance; it must not be a frustration, but rather a relaxation, an esthetic boost, a pride and joy. The color TV receiver, as the termination of the total color system, cannot make good color when poor is being received; but it can provide excellent color pictures from excellent transmissions and does so continuously and consistently with little or no attention.

The consumer is more strongly attracted to color when it can be easily installed under a wide variety of reception and environmental conditions.

Factory adjustments must largely prevail leaving only minimal degaussing, channel presetting, and antenna adjustments as necessary home installation requirements.

After installation, customer controls must be virtually self evident and stable. Long warm up or drift of any kind is frustrating under home conditions.

The performance must be good. Much is expected and much is necessary from a relatively expensive color set. In many respects performance must be better than black and white TV.

Service requirements, both in frequency and cost, should be comparable to a good black and white set. This means better quality components and circuits must be employed since more are used in color than in black and white.

Service procedures must, if anything, be simpler with more circuits to service. Adjustment requirements are desirably minimal in number. This may mean sophistication of design. (Adjustments cannot be used indiscriminately in lieu of careful control of design and component tolerances.)

The tuner antenna match, the r-f and i-f curve shapes, the oscillator stability, interfering cross modulation and "tweets" must be better than black and white. Sound circuits, luminance channel, chroma channel, sync, agc, deflection and convergence all have stringent requirements, particularly for stability.

The color TV receiver of today provides large, vivid color pictures of practical brightness, excellent contrast, saturation and resolution viewable in lighted rooms: doesn't require expert attention for months or even years. What other devices of comparable dynamic complexity have reached a similar state of technological development for the home?

PHILOSOPHY, CONT'D.

The public is becoming increasingly aware of the performance and reliability of color receivers. Demand for the last six months has exceeded supply. RCA sales are running 100% ahead in monthly sales of previous color sets. Virtually, all TV manufacturers are now or soon will be selling color TV receivers.

The Color Kinescope Story

The first 21 inch color TV receiver of seven years ago utilized the newly developed tricolor kinescope. The picture area was approximately 255 square inches, only slightly smaller than todays 261 square inch color picture. Little else, however, has remained the same. The tricolor kinescope has evolved over these seven years into a much higher performance, much more reliable, much more manufacturable television reproducer. The kine of seven years ago featured a metal cone, curved temperature-compensated shadow mask with about 350,000 holes, aluminized backing of the phosphors and magnetic convergence of the three electrons beams. The kinescope faceplate was 77% transmission. The safety glass used was direct transmission, consequently ambient light excited a great deal of reflection and glare to compete with the phosphor generated light. During the several years of manufacture of the metal kinescope, improved phosphor application techniques resulted in an increase of 50% in light output. Other manufacturing improvements were effective in improving high voltage arcs and other stability problems.

In 1957 the all glass tricolor kinescope was introduced. Several major advances were incorporated. Of particular importance was the graded hole shadow mask. The shadow mask holes were enlarged in the center of the mask from 10 mils to 12 mils diameter and decreased gradually in diameter radially from the kinescope center to the edge. The center holes had 144% of the area used in the preceding shadow mask. This at high beam currents resulted in 44% additional light output at the picture center area. However, the kine faceplate was made darker from 77% transmission to 72% so that about 39% net light output increase resulted. The two trips that ambient light must take through the faceplate, versus one trip for phosphor emitted light, increased the effective contrast correspondingly. An additional technique of tapering the holes larger towards the guns resulted in less shadowing or shaving of the beams as the beam angle of approach became less than perpendicular progressively towards the edges of the kine. The holes (or shadow mask at the holes) have less depth to angular beam approaches. This serves to increase light output relatively as the beams move from center. Also, since the holes are in effect larger, less precise shadow mask, beam trio and phosphor dot trio register are required. This eliminated the necessity for the heretofore used field-equalizer magnets around the kine faceplate periphery and their adjustment.

Another significant improvement resulted from the use of a molded or pressed kine faceplate. The contour of the inner surface was moldable to a more optimum contour for the phosphor screen, thereby, further relaxing the registry precision required. The new glass envelope during kinescope processing remained more stable and predictable insuring better maintenance of gun, shadow mask and phosphor alignment.

Early in 1961 another major advance in tricolor kinescopes was announced. The major new features included a new phosphor group with not only 50% greater light output, but, improved red and green persistence characteristics. The persistence of the light from the red and green phosphors now became as short as the blue. All are now comparable to the persistence of black and white kinescope phosphors. The yellow trail which was previously present in rapid action scenes was eliminated, providing sharper pictures. The new phosphors are of the sulfide type. The blue was already a sulfide.

The relative efficiencies of the three phosphors are such that the beam currents of the three guns are more nearly equal. Therefore, the spots produced by the three guns are more nearly the same size, and do not produce the red blooming and fringing characteristics which were apparent in previous color picture tubes.

Another major improvement is the use of a brazed cathode-grid assembly. Performance and reliability improvements have resulted from the new construction which holds the cathode rigidly in position, thereby assuring constant cathode-to-grid #1 spacing. As a result, the cutoff voltage characteristic of each gun remains stable. This new method of cathode support provides better control of cathode temperature, therefore, permits the cathode to operate at a lower temperature for prolonged useful cathode emission.

A third improvement is the use of a triple beaded gun mount. It is a more rigid structure with improved alignment of the three electron guns. A previous random degree of misconvergence with heating and cooling of the kine has now been eliminated.

Also in 1961 the bonded kinescope was announced. This new tube, having bonded "glare-proof" safety window, retains previous features and in addition provides greatly improved picture contrast, eliminates the need for an external safety glass in the receiver and diffuses annoying screen reflection of room objects. A filterglass protective window is sealed to the faceplate of the kine. This design utilizes a clear resin with the optical properties of glass between the faceplate and protective window, thereby eliminating reflections from two glass surfaces; consequently picture contrast and color saturation are improved. The surface of the protective window is etched finely to reduce specular reflection from the front surface. The net light transmittance of the laminated assembly is 43%. This is comparable to practice in similar black and white kinescopes. A color kinescope, because of its smaller deflection angle (70° versus 92° or 114°), and shadow mask has less internal bulb reflected electrons and light, hence, it is capable of producing a deeper black than most black and white kinescopes currently used. As a result the color kinescope is superior in contrast ratio to black and white kines, and desirably so, since even though its light output has been increased 2 or 3 times it is still not equally as bright as black and white.

Color kinescopes are now being made in the factory at the same shrinkage rates as black and white kinescopes. This is an interesting barometer of manufacturability.

Circuit Progress

In 1954 the 21 inch color television receiver was introduced. The earlier tricolor metal kinescope was used. The static convergence was electromagnetic on the theory that automatic tracking with line voltage and other variations would be obtained. However; in practice, offsetting instabilities in the available current for static convergence caused convergence shifts. Furthermore, high voltage arcs in the kinescope or other tubes caused surge currents which left residual magnetic flux in convergence assemblies, etc., to cause random convergence shifts. They dynamic convergence arrangements were interreacting and difficult to adjust.

Later convergence circuits use permanent magnet static convergence for stability and permanence. Dynamic convergence arrangements now have circuits that fix the center dynamic convergence and disassociate adjustment of top and bottom and right and left. For instance, convergence at the right of the picture may be individually adjusted without disturbing convergence on the center, left, top or bottom. The earlier convergence arrangements moved the beams individually on a diagonal without center stabilization. Radial movement and interreaction was confusing for most people; consequently, optimum convergence was not always accomplished. Improved convergence tolerance and stability of the present kinescope, plus improved circuits and adjustments now provide excellent results.

As those of you who have followed color technically know, the color system in its original and purist form evisions I and Q encoding and demodulation. The original 15 inch receiver did demodulate the I and Q phases. The first 21 inch set, however, started a trend of color demodulation circuit and system development; seeking the best practical color circuits for high quality mass production. The purism of I and Q was first modified to R-Y and Q demodulators using .5 megacycle bandwidth for the Q channel and 1.5 megacycle bandwidth for the R-Y channel. The wider 1.5 megacycle R-Y channel required a time delay filter to match the Q channel time delay. The Y, or luminance channel, (wide bandwidth) also must be time delayed to match the color channel phase. Problems of achieving and maintaining matched time delays were partial incentives for going, in later designs, to a single bandwidth for color of approximately .5 megacycle. The early practice of adding color and monochrome in adder tubes, amplifying and d-c restoring was found to be unnecessarily complicated. The kinescope, instead, was established as an adder by applying chrominance signals to the grids and luminance signals to cathodes. The d-c restorers have been eliminated by direct coupling when appropriate.

The modern color receiver has matured circuits and improved and quality components (tubes, capacitors, resistors, etc.) The blend of quality components and practical circuits has resulted in the currently used X and Z medium level (for stability) demodulators with equal chroma bandwidth (for minimum phase problems). These demodulators have approximately equal inputs and outputs for comparable linearity (and distortion). Matrix amplifiers following provide sufficient chroma without strain. The matrix amplifiers are operated with grids clamping and cathodes horizontally gated for stable d-c restoration and chroma amplification.

PROGRESS, CONT'D.

The early receivers attempted a difficult compromise by using a common video and sound detector. This was difficult because a slightly high sound carrier at i-f resulted in 920 kc beat between color 3.58 Mc and sound 4.5 Mc during detection. The critical sound trapping made fine tuning adjustment of the tuner critical and necessitated a very stable tuner oscillator, if periodic customer re-tuning was to be avoided. If sound was established slightly lower on the I.F. curve, inferior sound sensitivity and signal to noise ratio was likely. Now a separate sound detector and picture detector with appropriate trapping recovers the 4.5 Mc modulation and the 3.58 Mc modulation from different detection processes with, consequently, much less 920 Kc spurious beat developing. The tuner fine tuning becomes less critical, and practical for inexpert adjustment.

An application of negative mutual coupling to video bandwidth compensation yielded 30% greater luminance bandwidth for greater resolution on both monochrome and color transmissions. Automatic Chroma Gain Control has been tried in production receivers and discarded, perhaps temporarily, because of false action and undesirable subjective effect of increase of signal to noise ratio. Often low chroma modulation becomes noisy, hence, manual subjective chroma adjustment becomes desirable. Although chroma as low as 1/8 of full level can be useable, amplitude-wise in the color receiver, the subjective effect of signal to noise may be quite poor at full color channel gain. False automatic chroma control may result if burst is not directly related in amplitude variation to chroma. Past experience has shown burst amplitude often has no more relation to chroma amplitude than sync; hence, a good AGC is, practically, a good ACC.

The horizontal deflection and high voltage circuits and components have progressed from a relatively inefficient voltage doubler circuit to a single high voltage rectifier with a flyback transformer using super ferrite core, fire retardant impregnation, and a corona and fire retardant silicon rubber tire. The earlier failure prone focus pot has been succeeded by an inductive focus control of excellent reliability. Both horizontal and vertical output transformers utilize efficient bifilar windings. The 24,000 volts of regulated high voltage is capable of up to one milliampere of stable current.

Other circuits with common purpose to black and white television have progressed in performance and reliability with the best of the state of the art. The tuner used today, the Nuvistor, has much improved signal to noise ratio, gain, and preset fine tuning of high stability. I-f, sound, sync, AGC, noise inversion, horizontal and vertical, AFC and sync circuits are color-tailored versions of the best in black and white television.

Thus, it may be expected that the color receiver will perform with the best of black and white receivers and have comparable quality, the color kinescope and the color receiver itself have the same factory shrinkage and accelerated life test expected lifetime as the best black and white receiver.

Major Items of Quality and Life Improvement

in

7 Years of Color TV

In a device with as many diverse components and circuits as a color receiver, quality and performance stem from implementing a philosophy of quality over the total operation. Good quality is best designed into the product where feasible. Inspection and testing are then effective in assuring good performance and life in the consumers hands.

Currently running in the same factory in Bloomington, Indiana are the best black and white sets in America (if you'll accept my evaluation) and the best color sets. After all factory processes are complete and all sets are ready for shipment, a check of finished product produces figures of performance and quality almost identical between black and white and color. Furthermore, accelerated life tests under severe cycling conditions again spotlight a striking equality in percentage of sets that fail. Customer "use" reports also appear to find color TV equally as reliable today as good black and white sets. Our monitoring of field results, incidently, indicates that black and white sets have been reduced in failure rate to as much as one-fourth the failure rate of perhaps three, four, or five years ago with consequent reduction in frequency and cost of servicing. At least equally as remarkable is the comparison of the initial defect percentages at the black and white kinescope factory in Marion, Indiana and the color kinescope factory in Lancaster, Pennsylvania. They too are almost equal. Furthermore, accelerated life tests of the two types of kinescopes again indicates comparable life expectancy.

In the remarks on the progress in tricolor kinescopes a number of reasons for excellent quality are mentioned. A philosophy of quality is basic. All the many hundreds of components used in color sets have been subjected to an unrelenting quality improvement program. Assembly and testing methods, techniques and procedures have been subjected also to rigorous quality assurance programs. A high level quality committee composed of knowledgable, responsible people has sparked and monitored all TV receiver quality activity. To be effective, it was necessary to devise accurate measurement of actual (not presumptive) field failures.

Tubes and components that failed to perform either partially or fully have been returned from the field in full measure for analysis. Tests were then devised to measure before and during production similar possible failures. As tests became more accurate in predicting field problems, corrective action became possible before shipment.

Such problems as filament failures due to crystallization of wire, cathode pealing or poisoning, cathode interface problems, mica leakage, grid emission, structural deformation and many other malfunctions in vacuum tubes were radically improved by either design changes or quality control. The failure rate and life expectancy of tubes has been improved many times in recent years. Capacitors have been greatly improved for temperature stability, current leakage, voltage breakdown and especially for humidity induced problems. The now common epoxy dipped capacitors were first used in color TV to solve a serious problem of capacitor malfunction due to

IMPROVEMENT (CON'T).

humidity. The use was then extended to black and white TV. Resistors, too, have greatly improved for important characteristics. The 600 series color receivers, as some of you are perhaps firmly convinced, had troubles with focus potentiometers. Pots were improved but the solution was permanent with the change in design to inductance control of focus. Other problems with components have likewise been brought to bay. Our experience at RCA in assembly techniques has led to the adoption of precision assembly methods in our factory. Wire wrap terminals, pioneered and proved in telephone service, also add reliability to TV assembly. Etched precision circuitry in its developed form not only promotes peak, stable performance by precision wire dress and component relations, but also by enabling careful control of fluxing, cleaning and soldering, results in more reliable solder joints.

The change in value and damage of parts by a hand soldering iron is avoided by timed exposure to a solder bath, whose temperature is correct to within a few degrees.

Servicing

Even a very good TV receiver that is difficult to service will cause serious repercussions from at least two sources. The customer: who, when service is required, will be charged proportionately to the difficulty. The serviceman: becomes unenthused because he has problems commanding prices fully commensurate with the time involved. A labor charge of 10 or 15 dollars to replace a ten cent component is hard to justify. It is very important, therefore, that a TV receiver be as easy to service as possible. A committee of servicing experts was formed several years ago to recommend service features for our receivers. Many considerations are now included in the receivers to make servicing easier. A great many of the components and circuit connections are directly accessible on the chassis and printed circuit boards. The printed circuit boards have the wiring connections, parts and terminals clearly identified or "road mapped" on the top of the boards. Circuit tracing and parts identification are thus made simple and servicing is accelerated. Convenient, labeled test points are an additional service aid. The chassis may be easily positioned in the cabinet with full accessibility to top and bottom and virtually all parts for live or static tests.

The "service switch" on the chassis is a notably important addition in recent years. The switch removes vertical deflection and video input to the color kinescope. It is then an easy matter to adjust for equal cutoffs and drives on the three guns, and good tracking from high-lights to low-lights is readily obtained. The color temperature is specified to be set at 9300° Kelvin and +27MPCD, which is a warmer color than the 11000°K of black and white. Previous to the switch, a problem often arose when tracking set-up was made in high ambient daylight. The ambient tended to mask the cutoff settings in the low lights, so that in the evening low light color temperature was not satisfactory. The magnifi-

SERVICING (CON'T).

cation of cutoff light by the superimposition of the scanning lines, caused by no vertical scan, enables accurate low light settings in any ambient lighting.

A service position for the convergence panel is a great convenience for convergence adjustments, as any serviceman will agree.

Servicemen and Service Equipment

As many of you gentlemen are well aware, electronic equipment thrives only if those who service it are qualified and in sufficient supply. The success of color can hinge on the effectiveness of the technicians who attend it at all stages of the total system. In 1953 RCA started in earnest the development and sale of practical color test equipment and aids. The training of service technicians has been intensive in intervening years. It is estimated that in the last four years 10,000 servicemen from all over the country have been trained in RCA sponsored workshops. This training has been practical training, with commercial test equipment on commercial TV color receivers, involving realistic service problems. More than 150,000 people have attended RCA sponsored service lectures on color. The RCA Service Co., in addition, has 1,500 trained color technicians at 158 color equipped service shops throughout the country. The servicing fraternity is ready to cope with the booming sales of color receivers. I'm told, that NBC in the 1962-63 season will carry 2,000 hours of color programs. What will happen in color TV Broadcasting in total? We don't know-- but the color receiver is mature and ready.

Thank you

NATIONAL ASSOCIATION OF BROADCASTERS ENGINEERING CONFERENCE
CHICAGO, ILLINOIS
APRIL 1 - 4, 1962

Interim Report on WUHF

E. W. Allen

Station WUHF.

Television station WUHF (Channel 31, 572-578 Mc/s) is being operated for the Federal Communications Commission by the Municipal Broadcasting System of New York City for the purpose of evaluating the service which can be provided to that area by a high powered UHF television station.

The transmitter is an RCA TTU-50 A installed by the manufacturer on the 80th floor of the Empire State Building, New York City. It provides 25 kilowatts average aural power and 50 kilowatts peak synch power. Two antennas are being used during the tests.

A directional horn antenna, designed, built, and installed for the FCC by Melpar,* is mounted in a window in the northeast face of the Empire State Building on the 80th floor, 1010 feet above sea level. The antenna provides a smooth pattern centered at N 29° E, depressed 5° below the horizontal and having a 3 db beam width of ± 15°. The antenna will provide either horizontal or circular polarization, with a gain of 14.5 db horizontal, 14 db circular when received on a circularly polarized antenna or 11 db circular when received on a linearly polarized antenna. When fed with full power, the effective radiated peak synch power is in excess of 1 megawatt.

An omnidirectional antenna, also by Melpar, is mounted on the lower five bays of the steel tower atop the Empire State Building, the electrical center of the array being 1330 feet above sea level. It is a skew antenna having four panels, one mounted near each corner of the tower, so that the center of the radiation pattern forms an angle of 45 degrees with the tower face. Each panel consists of an end fed 6"x 12" waveguide provided with 24 vertical slots and with wings to shape the horizontal pattern. According to data obtained during the model tests, the four individual patterns merge to form a relatively smooth omnidirectional pattern having maxima and minima within ± 5 db of the average value. The vertical pattern is tailored to provide a relatively uniform field of about 110 dbu out to a distance of 7 miles, and provides a maximum effective radiation of 850 kilowatts peak synch at an angle of 2-1/2° below the horizontal.

Fixed location measurement procedures and equipment.

The U.S. Bureau of the Census has contracted to select 5000 random dwelling locations within a radius of 25 miles of the transmitter at which measurements of field strengths and observations of picture quality

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*IRE International Convention Record, 1962, "A UHF-TV Transmitting Antenna for the Empire State Building", R. W. Masters, S. R. Jones, A. Maestri and M. Parker, Melpar, Inc.

are to be made. A subsample of 1000 locations is provided at which 100 monochrome and 10 color receivers are to be installed in rotation, permitting observations by the dwelling occupants. Eleven crews of two men each, provided under contract by the Jerrold Company, are employed in this work, seven crews for locations where observations and measurements are made with portable monochrome receivers and field strength meters only, and four crews for locations where, in addition, receivers are installed for use by the tenant.

The portable field strength meter is a new VHF-UHF transistorised design built under contract by Smith Electronics. A tunnel diode voltage calibrator has been designed and built into the cover of each meter by the FCC Laboratory. The Laboratory has also built special antennas for the reception of circular polarization and VHF and UHF baluns for matching the receivers and the various antennas to 50 ohm coaxial transmission lines. The remaining equipment was selected from that available commercially after thorough type testing.* The portable receivers used for dwelling installation are selected from commercial types made by RCA, having 5 - 7 db noise figures at VHF and 9 - 11 db at UHF.

At each dwelling location an attempt is made to obtain a Grade 1 or Grade 2 picture at both VHF and UHF with an indoor antenna mounted in the same room with the receiver. For this purpose a tunable short dipole used at VHF and a bow-tie with corner reflector at UHF. If a Grade 1 or 2 picture at either VHF or UHF cannot be obtained with an indoor antenna, a roof antenna is used if physically possible and permission to mount one can be obtained. The measuring crews use a three element travelling wave antenna for VHF and a corner reflector for UHF on roofs. For VHF receiver installations a simple double V antenna, a three element travelling wave antenna or a more elaborate multiple V antenna is used to obtain a Grade 1 or 2 picture. For UHF receiver installations a corner reflector, a double V, or a multiple dipole with reflecting screen is used. Tubular foam-filled twin lead is used from the roof-top antenna to the receiver, separate leads for VHF and UHF for short runs, and single leads with dividing networks for long runs.

Mobile measurement procedures and equipment.

The mobile van is a Greenbrier Station Wagon fitted with a 30 foot pneumatic telescoping mast. The mast is rotatable from inside the van and is raised by pressure from a cylinder of compressed nitrogen. VHF and UHF antennas of various types can be fitted to the mast, but it will not support adequately a heavy antenna at 30' while the van is in motion. So for mobile measurements a dipole is used at VHF and a corner reflector at UHF. A 12 volt, 60 ampere, engine-driven generator, with storage battery, followed by an inverter unit, provides power for a portable television receiver, VHF and UHF field strength meters and a recording milliammeter. The milliammeter chart can be driven from the speedometer cable or by a clock drive.

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*IRE Transactions, November, 1961, "Performance Characteristics of Television Receivers and Antenna for the UHF-TV Project", E. W. Chapin.

Horizontal vs circular polarization measurements.

From October through November 25, 1961, the directional antenna was switched from horizontal to circular polarization at 30 minute intervals. Measurements and observations were made at the sample locations lying within the beam of the antenna, augmented by additional locations to increase the size of the sample. Mobile measurements at 10 feet antenna height were made along a radial at N 29° E, between 10 and 80 miles, and along two cross arcs at 23 and 40 miles from the transmitter. Right and left hand circularly polarized and linearly polarized receiving antennas during the circularly polarized transmissions and horizontally polarized receiving antennas during the horizontally polarized transmissions were used for both fixed and mobile measurements.

While the relative field strengths and picture qualities varied considerably at individual points, on the average no significant advantage of one polarization over the other was shown by either the fixed or mobile measurements. At very low field strengths the few measurements available show a slight advantage for circular polarization. Further tests with modified and more flexible receiving techniques appear to be desirable.

Directional and omnidirectional mobile measurements.

After the omnidirectional antenna was placed in operation on November 26, the 10' mobile run was repeated along the 29° radial and on the cross radial arcs at 23 and 40 miles. Using the directional antenna operating with horizontal polarization as a reference, the good agreement of the measured values gives some assurance that the antenna is operating as planned. The mobile measurements at 30' along radials at 29° and 50° reported below appear to support the conclusion.

Mobile measurements at 30' along radials.

A family of 8 radials has been laid out at 0°, 29°, 50°, 80°, 190°, 230°, 270°, and 340°. The departure from uniformity is caused by several factors, principally the proximity of water. Two of the radials, 230° and 270°, coincide with those measured by RCA several years ago. Between distances of 10 to 80 miles from the transmitter, the radials are marked off with measurement points at 2 mile intervals. With the proper antenna elevated to 30' and directed toward the television station, the field strength is recorded continuously as the van is slowly driven over a 100' run along the road nearest to the measurement point. Individual runs are made for television channels 2, 7, and 31. Measurements have been completed and analyzed for winter conditions on the 29° and 50° radials. The results are consistent with what has been found in previous surveys of this type. In the hilly terrain of the 29° radial the shadowing increases noticeably with increasing frequency as well as the range of variation of signal along the 100 runs. On the 50° radial, less hilly and partly over water, all three stations provide grade A signals generally out to about 55 miles. Beyond this the decrease in signal level is more rapid with increasing frequency.

Measurements at resident locations.

From data obtained in December and January, 100 random locations were selected where measurements and observations were made (but not installations) with antennas situated both indoors and on the roof-top of each location. There were 200 sets of measurements in this group, half at places where an indoor or "built in" antenna would normally be situated, and half on the roof-tops of these same locations. These were scattered over Manhattan Island and out to 25 miles from the Empire State Building. It should be emphasized that these measurements and observations constitute a very small sample and should be viewed with caution, as indicative of the service provided throughout the test area. The measurements give the following results.

Effective field strengths (dbu) exceeded by percentage of roof top measurements

	Channel 2	Channel 7	Channel 31
1%	117	114	117
10%	109	107	110
50%	91	93	98
90%	73	77	77
99%	63	48	55

Effective field strength (dbu) exceeded by percentages of indoor measurements

	Channel 2	Channel 7	Channel 31
1%	106	110	110
10%	90	86	87
50%	73	72	71
90%	57	55	55
99%	47	42	42

Median effective field strengths and building losses

	Channel 2	Channel 7	Channel 31
Median EFS, roof-top	91 dbu	93 dbu	98 dbu
Estimated transmitter ERP	16 dbk	20 dbk	29 dbk
Median EFS/kw, roof-top	75 dbu	73 dbu	69 dbu
Median EFS, indoors	73 dbu	72 dbu	71 dbu
Median EFS/kw, indoors	57 dbu	52 dbu	42 dbu
Building penetration loss	18 db	21 db	27 db

Picture quality observations.

Picture quality was graded at all locations using original TASO photographs* as a standard for judging degradation due to noise, and using a special scale for judging degradation due to ghosting which has been described in an ANIAC Report previously released by the FCC. Results of these observations may be tabulated as follows:

Thermal moise - percentage of locations where grade is equal or better

Picture Grade	Channel 2		Channel 7		Channel 31	
	Indoor	Roof-top	Indoor	Roof-top	Indoor	Roof-top
1	49%	94%	43%	91%	43%	89%
2	85%	98%	85%	97%	78%	97%
3	96%	100%	94%	100%	87%	99%
4	97%	100%	99%	100%	94%	100%
5	100%	100%	100%	100%	99%	100%
6	100%	100%	100%	100%	100%	100%

*Engineering Aspects of TV Allocations, TASO Report to FCC, March 16, 1959, page 254.

Ghosting - percentage of locations where grade is equal or better

Picture Grade	Channel 2 Indoor	Channel 2 Roof-top	Channel 7 Indoor	Channel 7 Roof-top	Channel 31 Indoor	Channel 31 Roof-top
1	31%	71%	32%	77%	32%	69%
2	77%	96%	68%	94%	68%	94%
3	95%	97%	91%	97%	86%	98%
4	97%	99%	96%	99%	93%	99%
5	100%	100%	99%	100%	98%	100%
6	100%	100%	100%	100%	100%	100%

Observations of picture quality have been made also at 100 locations at which receivers were installed. Outdoor antennas were required at 27 of the 100 locations. Roof top antennas were installed at 14 locations but access could not be obtained at 13. The trends follow those presented in the above tables for the observation and measurement locations. As stated above, it is believed to be too early to draw definite conclusions on the basis of the trends exhibited by the very small quantity of data analyzed so far.

Summary of measurements referred to in paragraphs 1 and 2, page 3:

Distribution of input voltages to 50 ohm receiver transmission line for horizontal and circular polarization measured at fixed locations

	Horizontal Polarization	Circular Polarization
1%	110	109
10	93	94
50	63	62
90	42	43
99	30	33

Differences in Picture Quality Ratings (Q) vs Receiver Noise (n), Ghosting (g) and Overall Quality (o) for Horizontal (h) and Circular (c) Polarization

	+3	+2	+1	0	-1	-2	-3	-4
Qnh - Qnc	1	4	33	193	29	3	0	0
Qgh - Qgc	2	7	37	168	39	6	1	1
Qoh - Qoc	0	9	47	165	37	5	0	0

Differences in median measured field strength between horizontal and circular polarization (Fh-Fc) for 100 foot runs at 30 feet antenna heigth, at distances between 10 and 80 miles along 29° Radial, Channel 31

Fh - Fc (db)	5.5	4.5	3.5	2.5	1.5	.5	-.5	-1.5	-2.5	-3.5	-4.5
No. of runs	1	2	2	3	6	4	3	3	2	1	1

errata:
Page 2, line 21, insert "is" before "used"
Page 3, lines 26 and 28, change "270" to "290"

POWER GAIN MEASUREMENTS ON AN INSTALLED TV ANTENNA

By

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INTRODUCTION

In principle, the task of determining the gain of a television transmitting antenna is simple. It could presumably be accomplished by performing two measurements. First, with a receiver in a service area, one would observe the signal from the antenna under test when it is energized with some known amount of rf power, P_1. Second, one would replace the antenna under test by a half wave dipole and measure the rf power, P_2, which would result in the same signal at the receiver. The power gain of the antenna under test is then P_2/P_1.

In practice this kind of a test cannot be performed because it is impractical to remove the transmitting antenna in order to install the dipole. But even if this were done, one would find the value of the gain only in one direction of the azimuth and the test would have to be repeated with the receiver located in other directions of the azimuth. This would be necessary because in general a television transmitting antenna does not radiate equally in all directions but has a horizontal directivity peculiar to itself.

The use of a dipole as a standard antenna is ruled out by the fact that the pattern of the dipole is materially changed by reflections from the supporting metal structure. It is therefore necessary to use as a standard, not a simple dipole, but a dipole equipped with an effective reflector which is a corner reflector, a triplane reflector or a parabolic reflector in order to make the radiation pattern of the comparison antenna essentially independent from the effects of the supporting tower.

A dipole with a triplane reflector is a small directional antenna. The gain of this antenna, with respect to a dipole, must be determined by separate tests in a laboratory. This can be done by taking a large number of radiation patterns to determine the values of the Poynting Vector over the surrounding sphere.

Once a suitable standard antenna has been constructed and calibrated, the comparative gain tests can be performed by comparing the signal from the standard antenna with the signal from the antenna under test with receivers placed at different azimuths in the service area surrounding the transmitting antenna. Since the comparison antenna is directional, it is necessary to turn it around, as such measurements are taken, so that the beam of the standard antenna would cover the direction of the receiver. If the receiver is located at some angle with respect to the maximum of the beam, an appropriate correction is made.

Since the object of the transmitting antenna is to deliver a signal to a certain service area, the gain should be tested at representative distances, perhaps 10 or 20 miles away from the antenna, although with due allowances for the vertical pattern, shorter distances could be used. At distances between 5 and 20 miles from the transmitting antenna, one may assume that the receiving antenna would be placed at various heights, from a few feet above the ground tops of apartment buildings. A large number of receiving antennas in residential areas would be a 10 or 15 feet above ground. It would seem logical therefore that the gain tests should be performed with the receiving antenna located at, say 10 or 15 feet above ground.

Assuming that the standard antenna has been properly calibrated, the test procedure outlined above could be expected to result in a reliable value of gain, if the comparison antenna could be placed at the center of radiation of the antenna under test. Since in practice, this cannot be done, the standard antenna must be placed either below or above the television antenna under test and it is, therefore, necessary to make corrections for the disparity in the heights of the two antennas. A discussion of such corrections will be found later in this paper.

Measurement techniques discussed in this paper were used to measure the power gain and horizontal pattern characteristics of the KMOX-TV antenna in St. Louis, Missouri. KMOX-TV, Channel 4, St. Louis, is one of the key stations of the CBS Network in an important market. To measure the performance of the antenna an extensive program of field measurements was worked out with Andrew Alford Consulting Engineers, CBS Engineering in New York, and the General Electric Company.

The KMOX-TV antenna is a custom built helical antenna designed by the General Electric Company and installed around a 5 ft. 3 in. triangular tower section.

At the start of this investigation, it was hoped that the comparative measurements in a large number of directions of the azimuth could be avoided by flying a helicopter in a circle around the transmitting antenna and recording the signal from the antenna under test. Several such patterns were recorded and at two different distances from the antenna. These tests yielded an approximate shape of the horizontal pattern of the antenna but they, when taken alone, were not sufficiently accurate to enable one to determine the RMS gain by making gain comparison measurements in just one or two directions of the azimuth.

It was also expected that by flying the helicopter up and down it would be possible to compare directly the signals from the two transmitting antennas without the necessity of making corrections for the difference in the heights of the two transmitting antennas. This expectation seems to have been realized.

The helicopter tests will be described in some detail because they not only give a general picture of the behavior of the radiated field, but also have a direct bearing on the interpretation of the results obtained on the ground with a field car, which were found to be increasingly more useful as the investigation progressed.

II

REFERENCE ANTENNA

Since none of the field work could be initiated until the reference antenna was available, the design and production of such an antenna received first priority. This antenna had to be strong, light and be capable of being readily assembled and disassembled to permit its passage through the interior of the KMOX-TV tower, sections of which were partially obstructed by another antenna array at a lower level of the structure.

It was deemed essential that the reference dipole be equipped with a triplane reflector which would suppress the back radiation to a very low level, in order to keep the tower members from being illuminated and causing unwanted reflections. See Figures 2 and 3. The antenna was designed after a number of model measurements, with and without a model tower. The impedance of the full scale final reference antenna with the reflector was adjusted until at the visual carrier frequency, 67.250 mc, the SWR was 1.03:1 as shown in Figure 4.

To determine the radiation pattern of the reference antenna, an accurate scale model was built, since various parameters of the dipole and reflector could be more readily adjusted in a model of convenient size than in the full scale antenna. Additional patterns were taken with the model antenna mounted on an accurate scale model of the adjacent section of the tower including guy wires to determine their effect on the pattern. Some distortion was introduced by the proximity of the structure, but the change in the pattern was small. The power gain of the reference antenna was found from these radiation patterns and from comparison tests using a standard dipole to be 4.25 over a dipole in free space.

III

VERTICAL RADIATION PATTERNS

Early in November of 1960 the reference antenna was installed just below the base of the KMOX-TV Helical Antenna. During the latter part of this month, engineering personnel of the three organizations concerned undertook the initial measurements.

A helicopter, equipped as described and as shown in Figure 9, was flown to a site 15.5 miles distant and on a bearing of 44° East of North from the transmitter. Here the craft has taken to altitudes ranging from ground level up to 600 or 1250 feet above it in as nearly a vertical path as could be maintained by the pilot. The ascents from ground level up were performed first with the Helical Antenna energized and then the reference antenna. The resultant fields were recorded during the flights. An effort was made to monitor and to keep constant the transmitter power during the measurements.

Two methods were employed in recording the received signal. First, the engineer operating the equipment would manually record the field intensity at 50 foot intervals, starting at 50 feet above ground level and continuing up to the highest altitude attained. In the second procedure, a recorder* was fed directly from the output of a field intensity meter**. This system yielded continuous field strength data from 50 to 1250 feet above ground. Figures 10 to 14 show the plotted data obtained from each run.

This process was repeated at two other tests sites; one located at the northern edge of the Lambert Field Airport, 16.1 miles from the transmitter and at a bearing of 346°; and the other 11.0 miles away at a bearing of 182°. This last site was across the Mississippi River in Illinois. Figures 15 to 20 show the results of the data taken at these two points.

Several comments are in order pertaining to the graphs made of this data. It will be noted that in some instances in which the curves are plotted as an average of several runs, there is a fairly wide dispersion of points for a given altitude. This can be at least partially explained by the inability of the pilot to hold the helicopter in a constant altitude and oscillating back and forth about a vertical axis. Another factor involved was the tendency of the pilot to drift either forward or backward from his reference point on the ground.

There is a difference in height at which maximum signal occurs for each antenna. This may be expected from the difference in position of radiation centers that the Helical Antenna being about 50 feet above that of the reference antenna. See Figure 22.

The data obtained at the 182° test site exhibits some features of its own. See Figures 15 to 17. These curves indicate that there is an area of high signal encountered between the two maxima expected over flat ground. This sandwiched maximum is of a lower magnitude than the main maxima. An investigation of the terrain showed a row of bluffs along the western edge of the Mississippi River on the line between the transmitting tower and the test site. These bluffs represent a rapid change in ground elevation which is believed to be capable of accounting for the extra maximum.

In fact, as long as the helicopter is near the flat ground the reflection takes place from the ground or from the surface of the river. At higher elevations the reflected signal comes partly from the lower flat ground and partly from the tops of the bluffs. The latter signal is believed to be responsible for the intermediate extra maximum. The phenomena are sufficiently complex to require modeling in order to completely verify the above explanation. Elementary computations result in a semiquantitative agreement.

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*Manufactured by Texas Instruments
**Manufactured by Nems Clarke

IV

HORIZONTAL RADIATION PATTERNS

The second phase of testing required the helicopter to circle the KMOX-TV Helical Antenna to obtain horizontal patterns. Two circles were flown at 1000 feet above average terrain. The small circle had a radius of 3500 feet; the large circle had a radius between 2.4 and 2.5 miles. The radius of the large circle was selected so, assuming flat ground, the reflected signal from the ground would have to emanate from the first null in the vertical pattern in order to intersect the 1100 foot level at the large circle. For pattern measurements of this kind, a low level of reflected signal is desirable because this signal tends to add to the direct signal in various phases making the total signal irregular.

A number of flights were made and their average results were plotted with certain results obtained a year ago. A pattern taken with a scale model antenna made by the General Electric Company is also plotted. While some deviation is apparent, the several curves are quite consistent in general shape.

Figure 25 is a section of one of the tapes on which the horizontal pattern was recorded. The fluctuations were averaged to yield a smooth curve on the assumption that the rapid changes in level were due to ground reflections.

One difference should be noted between the conditions existing during the flights used to obtain the vertical patterns and those used to obtain the horizontal patterns. In the former flights, all measurements were made early in the morning when the station was not broadcasting regular programming. This permitted the use of an unmodulated carrier frequency. In the latter flights, the work was performed during daylight hours to enable accurate navigation of the circle. During this period, the normal broadcast signal was utilized.

V

AN ATTEMPT TO DETERMINE THE RMS GAIN OF THE HELICAL ANTENNA FROM HELICOPTER MEASUREMENTS

The field measurements described above yielded the ratios of the field F_h of the Helical Antenna to the field F_s of the standard antenna. If the gain $G_s = 4.25$ of the standard antenna is multiplied by $(F_h/F_s)^2$, the product is the gain G_h of the Helical Antenna in the direction along which $(F_h/F_s)^2$ was measured. If G_h could be obtained in this way in a large number of more or less equally spaced directions, the RMS gain G_r could then be computed by simply taking an average of the values of G_h in the various directions. Since vertical helicopter runs for determining G_h were both time consuming and expensive, it was decided to make such measurements only in relatively few directions and supplement them with horizontal patterns accordingly. The adopted procedure consisted of the following steps: a) the selection of the best available horizontal radiation pattern of the antenna under test; b) determination of the ratio F_r/F_h of the relative RMS value of the field of the pattern to the relative value of the field as read from the pattern in the azimuth direction in which F_h was measured. The RMS gain is then obtained by multiplying $(F_r/F_h)^2$ by the measured value of the gain G_h. If the horizontal pattern were accurately known, a single calculation of this kind would give the RMS value of the gain. If F_h/F_s were accurately measured in several directions and the horizontal pattern were correct, identical values of the RMS gain would be expected regardless of which set of data were used.

The table in Figure 24 shows the values of the RMS gain which were obtained by applying this method of horizontal patterns and the values of gain G_h established as a result of helicopter measurements at the three azimuths (44°, 182° and 346°).

The results in Table 24 seem to show that none of the horizontal patterns are sufficiently accurate to give completely consistent values of the RMS gain. It is believed that the results would have been somewhat more uniform if the measurements of F_h/F_s were made in the directions of the maxima of the horizontal pattern rather than at the azimuths which were selected on the basis of flat terrain.

FIELD CAR TESTS

Because the results in Table 24 left something to be desired, it was decided to obtain additional values of F_h/F_s at other azimuths. This task was greatly simplified by the fact that a comparison of values of F_h/F_s measured using a field car was found to be in very good agreement without exceptions with the values of F_h/F_s obtained from the helicopter runs.

When additional field car measurements of F_h/F_s became available, it was possible to plot all of the data on a single polar chart.

The following is a quotation from a letter of April 18, 1961, written by Mr. W. A. Fitch of CBS in which he describes a typical set of such measurements.

> "The measurements were made using the CBS Engineering field car with the receiving antenna at a height of ten feet. At each measurement point the car was driven a distance of approximately 100 feet with the KMOX-TV Helix Antenna transmitting. The relative field strength was recorded with the BW-7A measuring set in the linear position. Then the same traverse was repeated a few moments later and measurements made with the standard antenna transmitting. Mobile telephone communication enabled the antenna transfer to be made at KMOX-TV as desired.

"All the measurements were made after tne end of the broadcast day, approximately from 2:00 a.m. to 5:00 a.m. A C.W. power of 1500 watts from the driver was used for all measurements.

"The following method of recorder tape analysis was followed. Each measured recording was divided into ten equal sections. The field strength exceeded 50% of the distance for each sector was determined. Then the average of the ten sector field strengths was taken as the field strength for the point.

"So far five radials have been measured. The 165°, 183°, and 200° radials were measured during March with the standard antenna oriented N 183° E. The 130° and 145° radials were measured during April with the standard antenna oriented N 145°E.

"The measurement points were selected during the daytime with the object of finding points as free of diffraction, obstructions, buildings, and wires as possible. In all cases the measurements were made within 1/2 degree of the assigned radial. None were closer than 6 miles. The following table gives the distance to each measurement point and the ratio of the Helix field strength to the standard dipole field strength at each point. The average ratio for each radial is also given."

KMOX-TV
SUMMARY OF COMPARISON MOBILE MEASUREMENTS

MARCH - APRIL, 1961

	130°		145°		165°		183°		200°	
Point No.	Dist. Miles	Ratio	Dist. Miles	Ratio	Dist. Miles	Ratio	Dist. Miles	Ratio	Dist. Miles	Ratio
1	19.9	1.32	18.6	1.27	18.6	1.17	9.5	.87	20.4	.785
2	19.1	1.33	17.8	1.25	18.4	1.225	11.0	.913	19.4	.805
3	18.2	1.33	16.1	1.39			12.2	.852	16.8	.75
4	17.3	1.38	15.6	1.23	17.4	1.10	12.5	.91	14.9	.83
	12.35	1.39	14.2	1.30	15.5	1.24	12.7	.925	12.9	.86
6	12.05	1.33	13.4	1.25	14.0	1.12	12.9	.953	12.4	.93
7	11.1	1.29	13.0	1.28	13.2	1.06	14.2	.847	11.8	.87
8	9.6	1.31	12.6	1.28	13.0	1.10	15.5	.870	10.8	.825
9	8.3	1.15	11.9	1.34	12.6	1.00	15.9	.877	9.4	.74
10	7.0	1.25	10.0	1.25	11.6	1.02	16.3	.759	9.0	.733
11	6.85	1.20	7.4	1.14	9.0	1.165	17.7	.843	8.0	.74
12					6.2	1.165	18.6	.855	6.9	.768
Average Ratio	F_h/F_s	1.30		1.27		1.12		.872		.802

Subsequently, a number of other measurements along additional radials were made by Mr. Fitch.

Although the field car measurements were not corrected for the difference in the height of the centers of radiation of the two transmitting antennas, the agreement between the helicopter data and the field car data in directions in which both were available is believed to be significant.

INTERPRETATION OF DATA

One of the reasons for choosing the 44° site was that at this site itself and for some distance from the site toward the transmitter, thr ground was approximately flat and clear. For this reason, data showing the field as a function of height may be expected to be in at least approximate agreement with the theory. Inspection of Figures 10, 11, 12, 13, and 14 shows that there is some spread between individual helicopter runs. On the whole, however, the data is in agreement with what may be expected. Figure 30 gives a comparison between theoretical curves calculated from equation (10a) using R = .82 and R = .975. The value of R = .82 was chosen emperically on the basis that it seems to result in the best overall fit of the experimental data. The dotted curve was calculated on the assumption that h_1 = 900 feet. This lower transmitting antenna height is in effect an allowance for sloping ground. See Figure 30C.

The relatively low value of R seems to be ar variance with the calculated values of R given in Table II. The most likely explanation of this deviation is that the ground is effectively fairly rough. The emperical value of R is based primarily on the relative depth of the first minimum which occurred at about 600 feet above ground. In this case, the reflection took place over a larger area which probably included not only small hills and dales, but also some buildings and trees.

It is possible that a somewhat higher effective value of R would be observed when a receiving antenna is at, say, 10 or 15 feet above ground because in this case the area of ground which contributes to the reflected signal is relatively small and is located closer to the receiving antenna.

During the tests, the height of the helicopter was measured with an ordinary altimeter which was not sufficiently accurate to be used below 50 feet. No data was, therefore, taken below 50 feet.

Figure 31 shows a comparison of theory with measurements made by Mr. W. A. Fitch of CBS at two clear locations in Long Island, New York, using TV Channel 4. The rather sudden drop-off below 11 feet is believed to be due to the proximity of the receiving antenna to the roof of the field car. Except for this drop-off, the data seems to support a value of the reflection coefficient around .82.

The helicopter data taken at the 182° site and shown in Figures 15, 16, and 17, is similar to that taken at the 44° site except that the behavior of the field versus height curve above 300 feet is not at all like that indicated by the simple theory outlined above, see Figure 32. The reason for this behavior is believed to be related to the shape of the profile of ground between the transmitter and the 182° site. When the helicopter is flying at a relatively low altitude, the effective reflection takes place from the flat ground near the 182° site. At higher altitudes of the helicopter, additional reflections are received from the higher ground on opposite side of the river. It is this second reflected signal which is believed to account for the filling of the first minimum of the field-height curve. The regular behavior below 300 feet indicates that the reflection takes place from a flat area. Because of this regular behavior, determination of the relative gain of the two antennas by taking the ratio of the peaks is believed to be justifiable.

The field-height curves taken at the 346° site exhibits an upward shift of the first maximum to a degree which has not been encountered at the other two sites (see Figure 33). This upward shift of the maximum can be explained by assuming that the reflection took place on flat ground which is tilted slightly upward toward the transmitting antenna. From Figures 31 and 30C it may be seen that a tilted ground results in a change of the effective height of the transmitting antenna. A ground slope of only 52.8 feet per mile over the effective reflection area would have reduced the effective height of the transmitting antenna by about 500 feet and would have raised the calculated height of the first maximum in the field-height curve by almost a factor of 2.

Because of the similarity of the field-height curves obtained with the standard antenna and the helix, it is likely that the gain obtained by taking the ratio of the peaks of the two curves is regarded as reliable although, in view of the relative irregularity of the curves, this data should be given a somewhat lower weight than the data obtained at the other two sites.

DISCUSSION OF THE FIELD CAR TESTS

The effective value of the reflection coefficient obtained from the helicopter measurements at the 44° site was .82. The reflection coefficient could not be deduced from measurements at the 182° site because of the reflections from the top of the bluff across the Mississippi River. The value of the reflection coefficient which was obtained from the helicopter measurements at the 346° site is .67. The only likely explanation for these relatively low values of reflection coefficients is that the ground was not perfectly flat, even at the places chosen for their relative flatness. The map shows that the ground affecting the reflected signal observed during the heliocopter flights at the 346° site is rougher than the corresponding ground in the neighborhood of the 44° site. This is in agreement with the lower value of the reflection coefficient observed at the 346° site.

According to a suggestion by Lord Rayleigh, the quantity which provides a measure of surface roughness is $\frac{4\pi H}{\lambda} \sin\psi_2$ where H is the difference in elevation between the high and low spots and ψ_2 is the angle between the average reflecting surface and the reflected ray. From Table I under Discussion of Results, it may be seen that ψ_2 varies relatively little when the height of a receiver 10 miles from the tower is changed between 600 and 10 feet. For this reason, it may be expected that the reflection coefficient determined from measurements at 300 to 600 feet should still be roughly the same as that which would be effective at 10 feet. This would mean that the values of the reflection coefficient to be assumed in interpreting the field car data should be .8 or .7, depending on the roughness of the "flat terrain" in which the measurements were made.

If this is the case, the rather good agreement between the field car data with the helicopter data, becomes understandable.

CONCLUSION

Techniques have been described for the measurement of horizontal radiation patterns of a television antenna directly by means of a helicopter and for the determination of absolute gain by comparison with a reference antenna using measurements made both by helicopter and field car. The results of these measurements were analyzed and it was shown that the helicopter provides suitable qualitative measurements of the antenna pattern and that both helicopter and field car can provide quantitative measurements of antenna gain. The reduced operating cost and additional convenience in the use of a field car recommends it, in conjunction with a suitable calibrated reference antenna, as the preferred means of making absolute gain measurements.

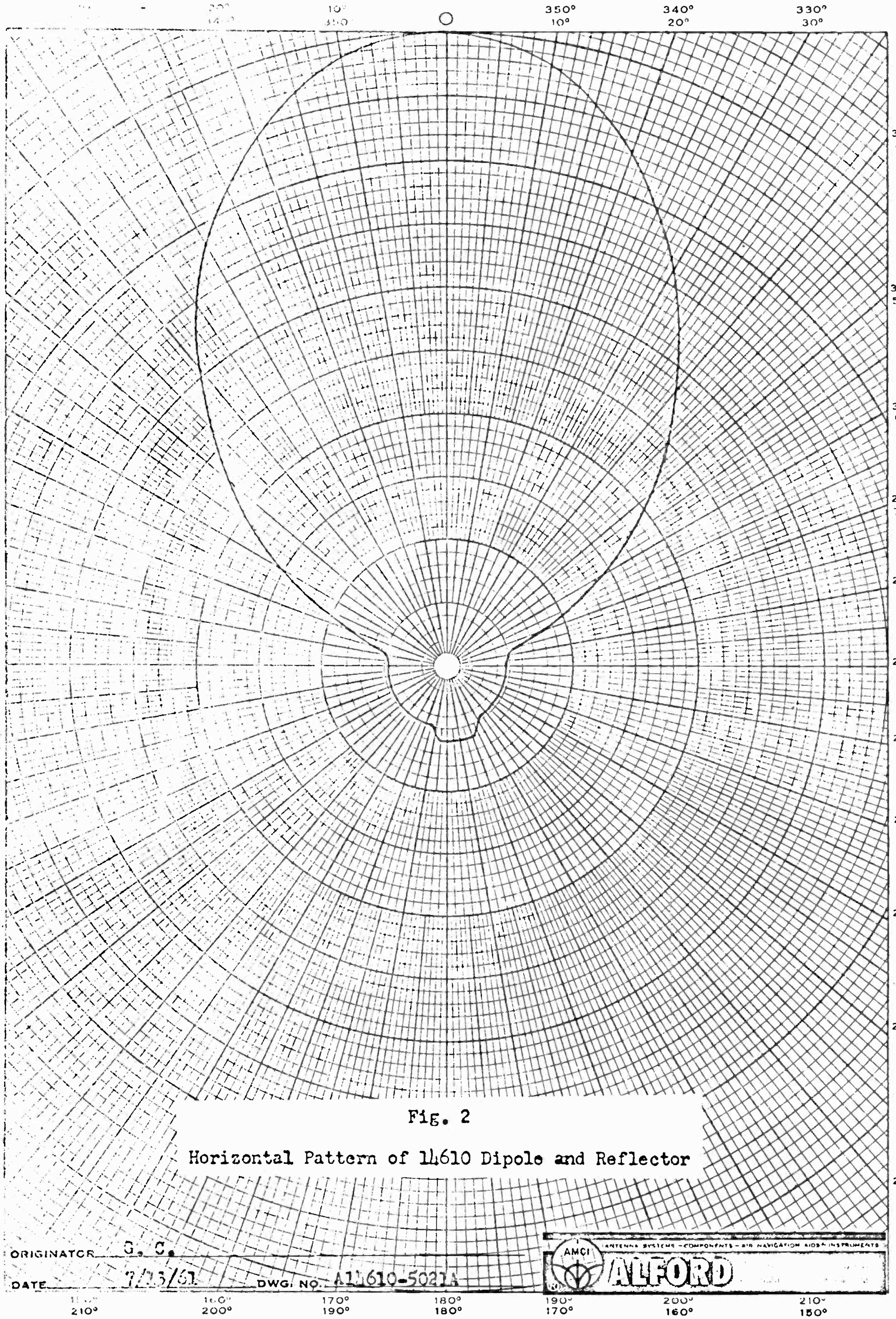


Fig. 2

Horizontal Pattern of 14610 Dipole and Reflector

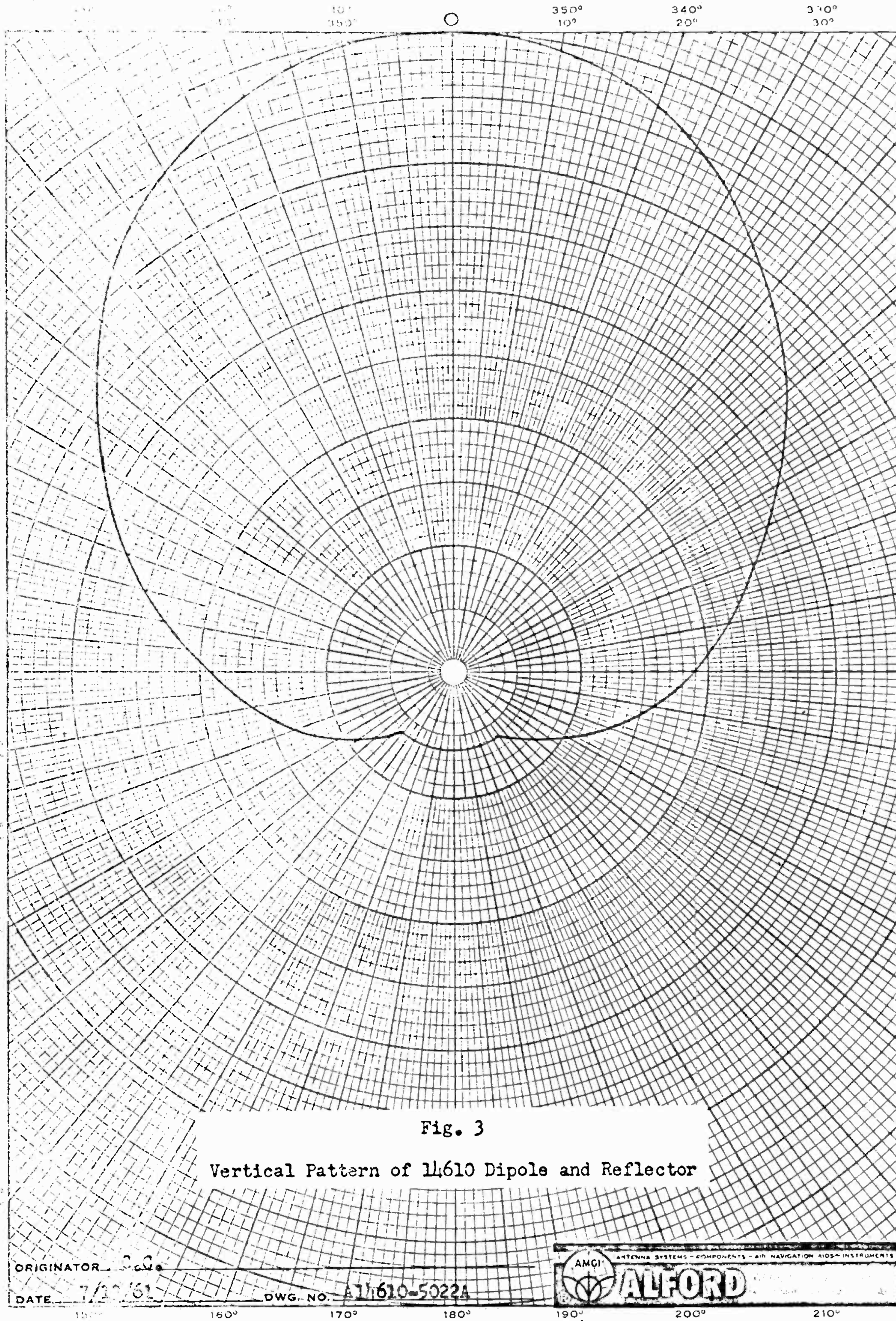
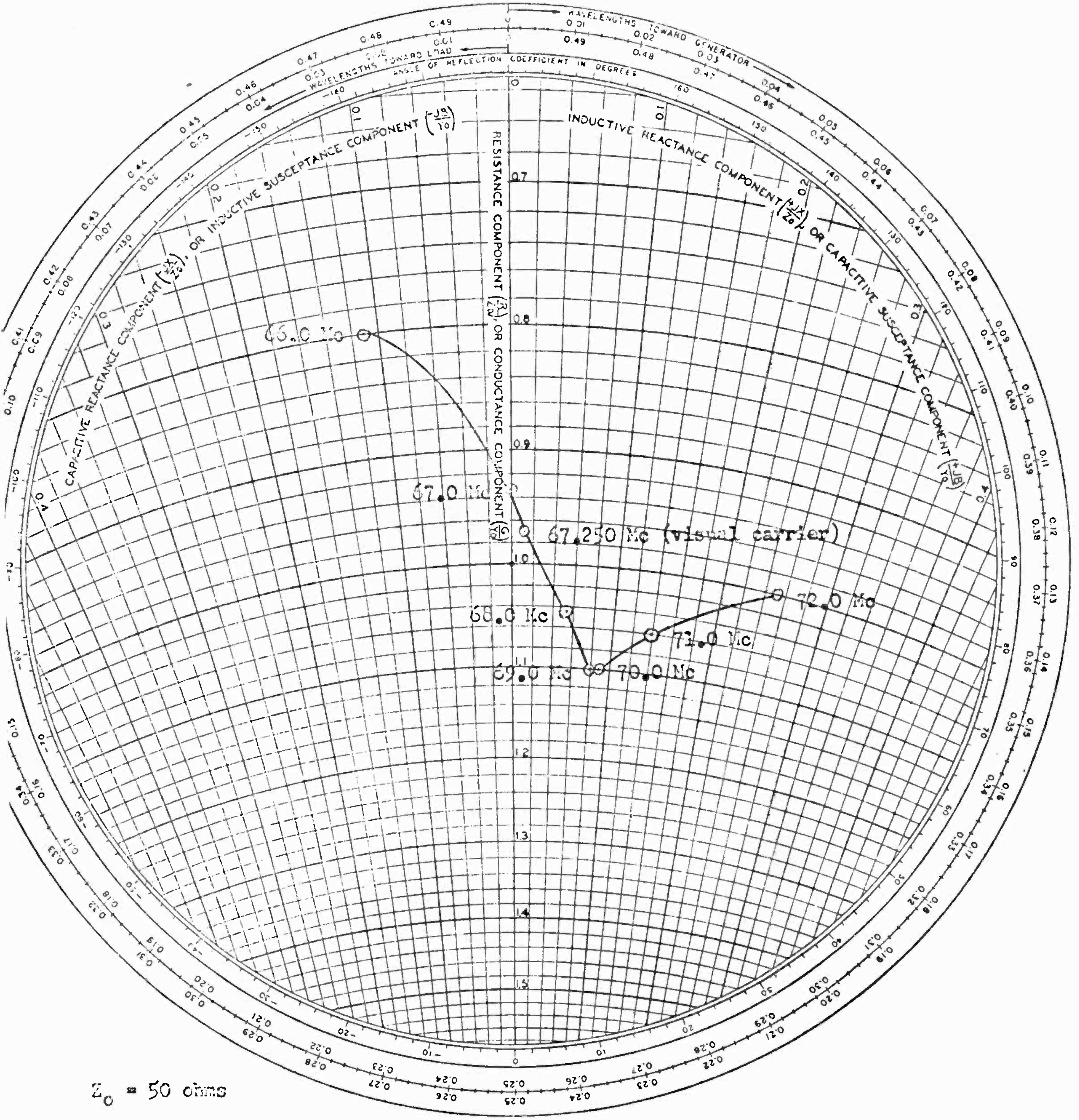


Fig. 3

Vertical Pattern of 14610 Dipole and Reflector



Z_0 = 50 ohms

Referred to input of compensating line section.

Fig. 4

Impedance of Reference Dipole

ALFORD MANUFACTURING COMPANY

DWG. NO. A14610-5020A

FIG. G.C. DATE 7/5/61

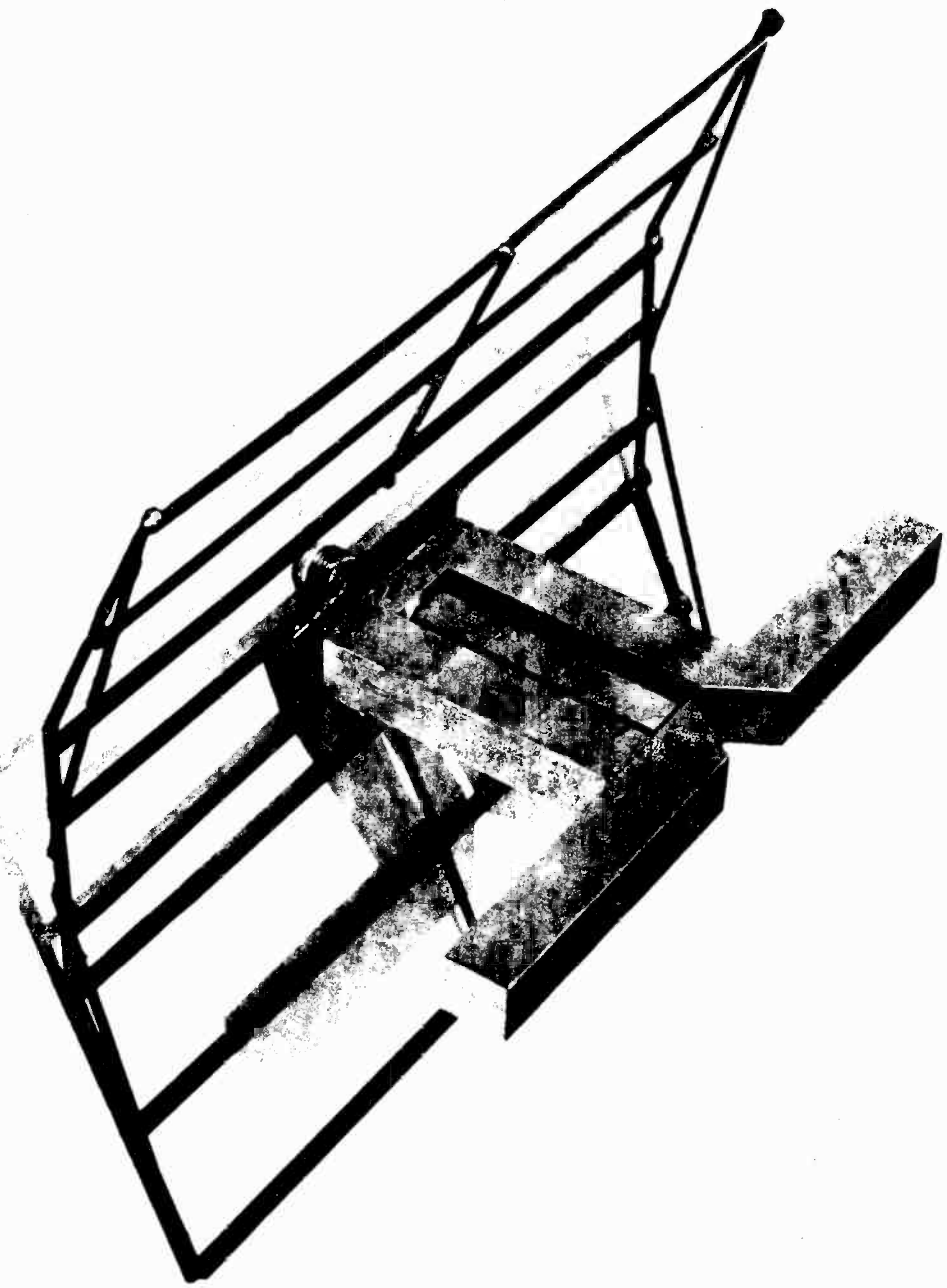


Figure 5

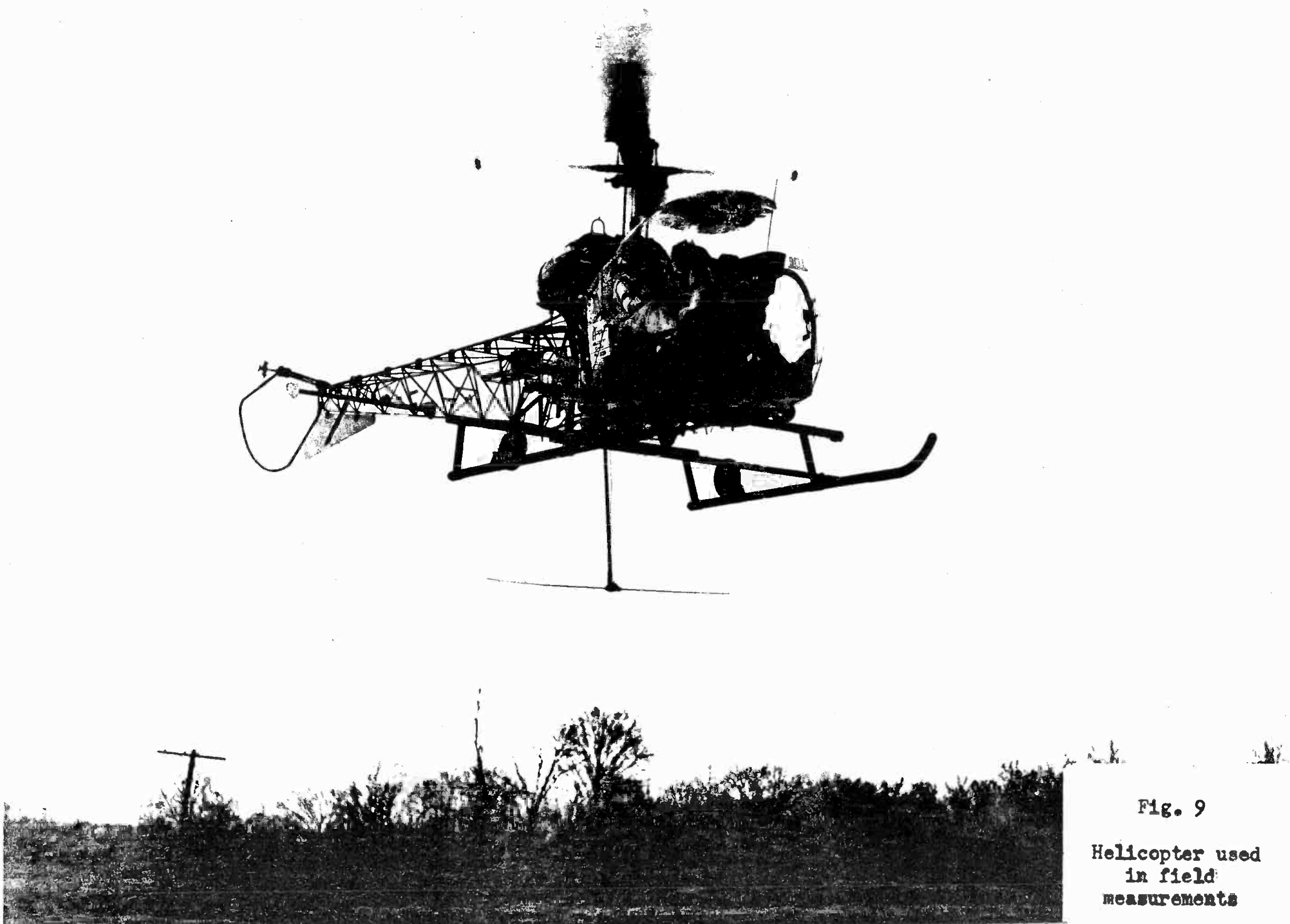
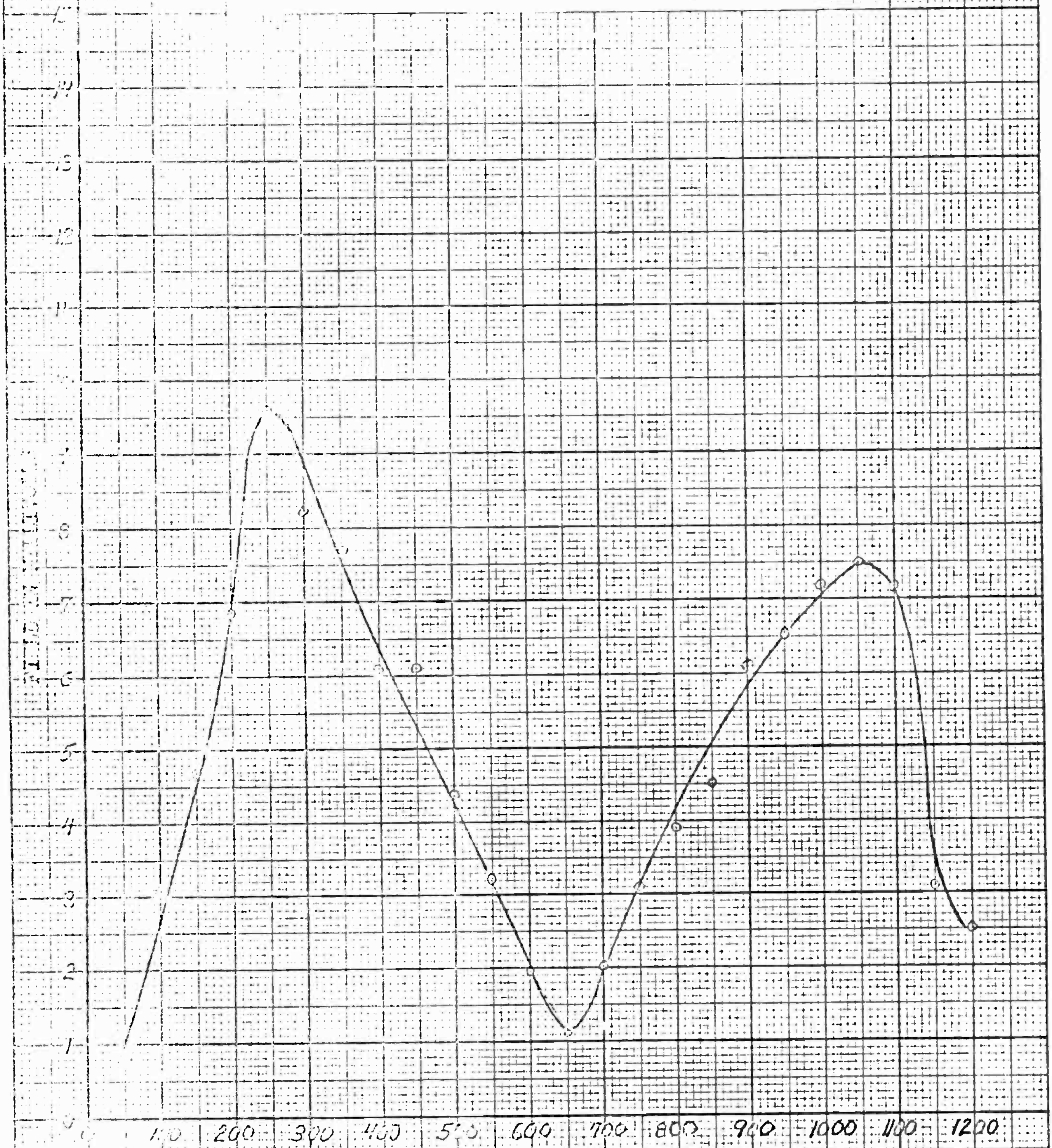


Fig. 9

Helicopter used
in field
measurements

FIELD VS ALTITUDE FOR KMOX-TV CH. 4 HELIX

AT 44° TEST SITE

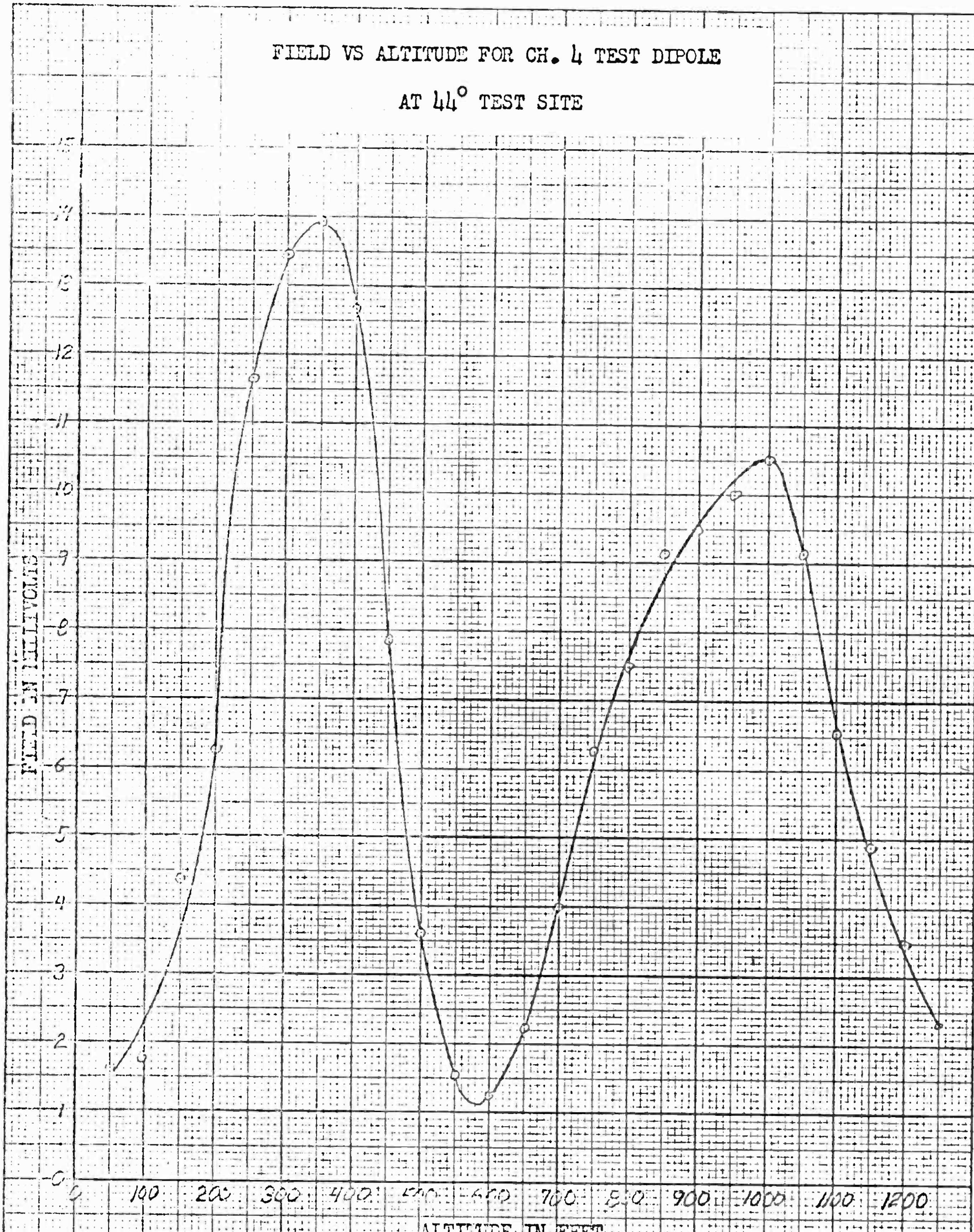


NOTE:
FROM RECORDER TAPES TAKEN ON 11/18/60

Fig. 10

ANDREW ALFORD
CONSULTING ENGINEERS

DR. BY G.C.
DATE 12/13/60
TITLE
DWG. NO. A14610-5004



NOTE:
FROM RECORDER TAPES TAKEN ON 11/18/60

Fig. 11

ANDREW ALFORD CONSULTING ENGINEERS

DR. BY C.C.
DATE 12/13/60
TITLE
DWG. NO. A1 610-5003

AACE FORM 1000-60.038 B

FIELD VS ALTITUDE FOR KMOX-TV CH. 4 HELIX

AT 44° TEST SITE

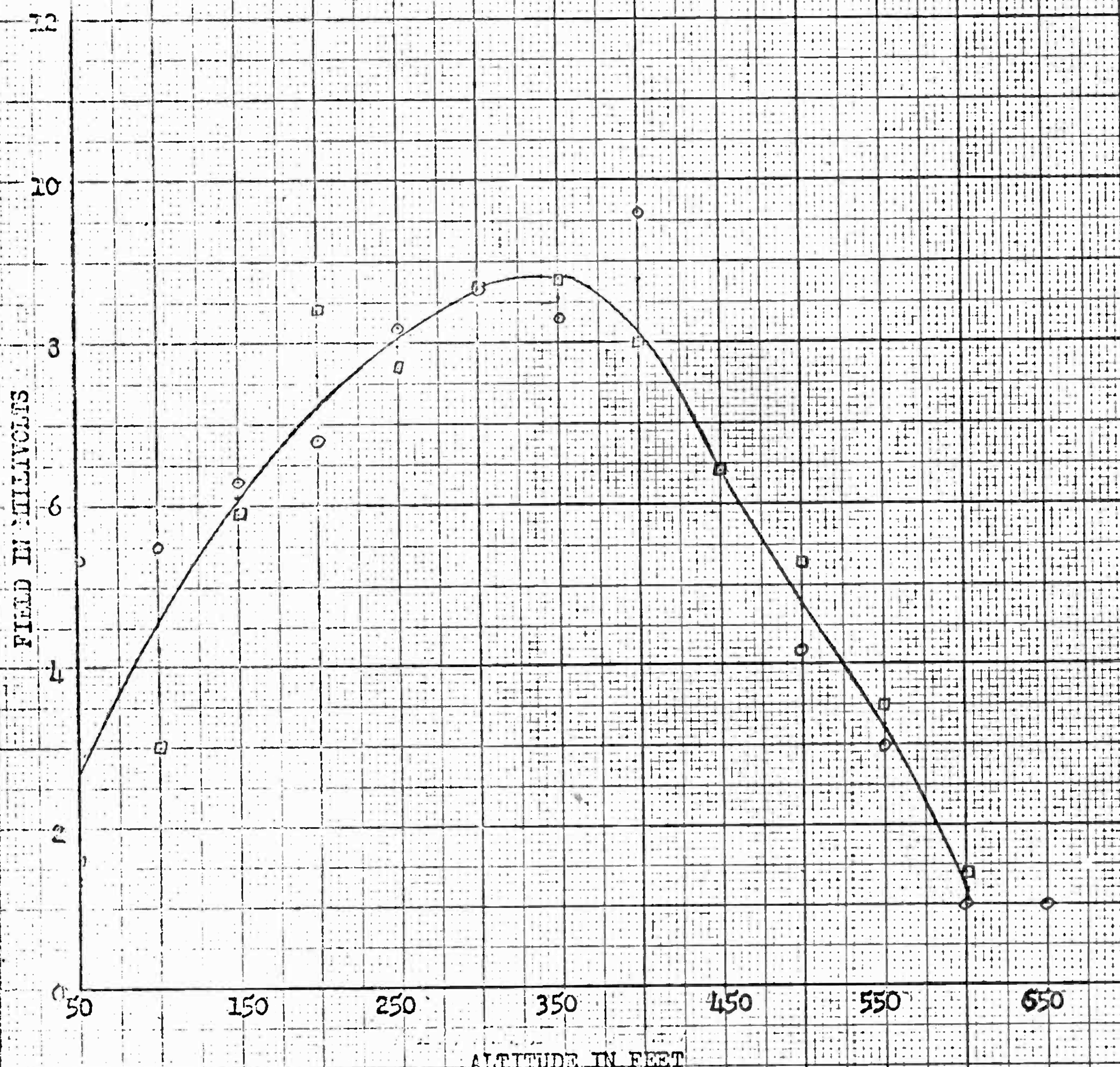


Fig. 12

ANDREW ALFORD
CONSULTING ENGINEERS

DWG. NO. A14610-5001A

FIG. G.C. DATE 11/25/60

NOTE:
FROM DATA TAKEN MANUALLY ON 11/17/60

FIELD VS ALTITUDE FOR CH. 4 TEST DIPOLE

AT 44° TEST SITE

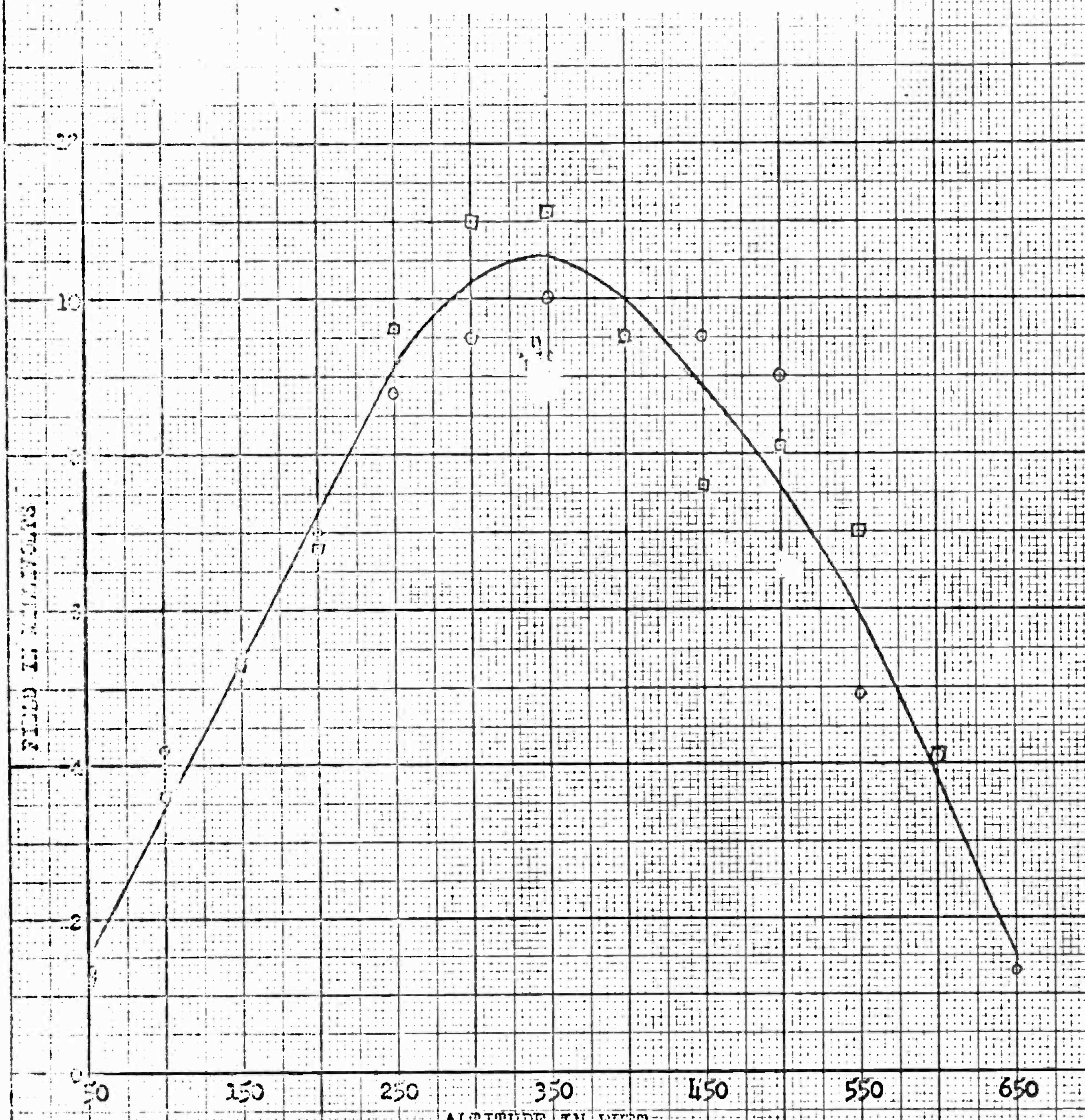


Fig. 13

ANDREW ALFORD CONSULTING ENGINEERS

Dwg. No. A14610-5002A

Fig. G.C. DATE 11/25/60

NOTE:
FROM DATA TAKEN MANUALLY ON 11/17/60

FIELD VS ALTITUDE FOR CH. 4 HELIX AND TEST DIPOLE

AT 44° TEST SITE

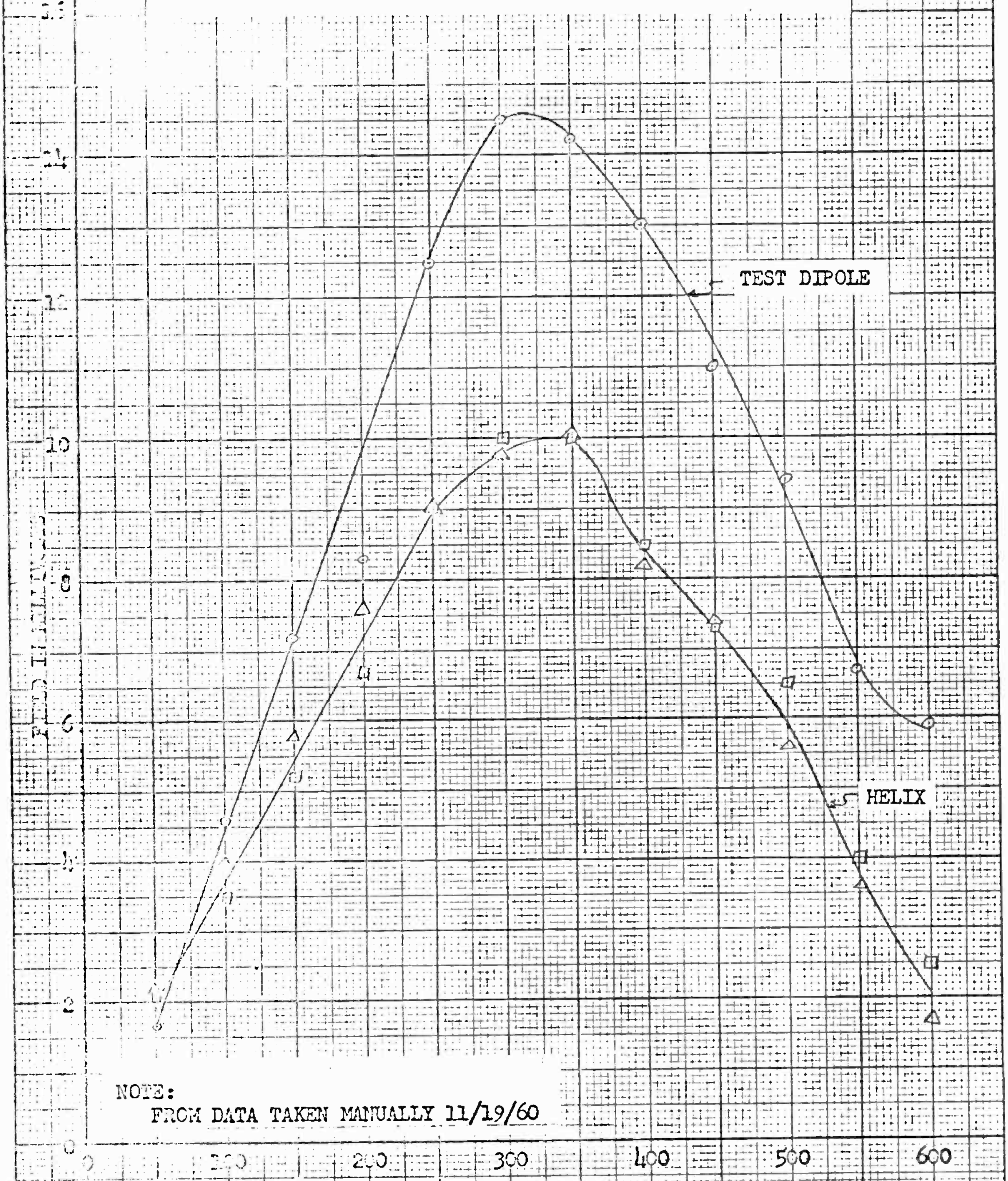


Fig. 14

SPAULDING MOSS COMPANY BOSTON 10, MASS. MADE IN U. S. A.

10 X 10 PER HALF INCH

ANDREW ALFORD CONSULTING ENGINEERS

DR. BY G.C.

DATE 11/30/60

TITLE

DWG. NO. A1460-5005

AACE FORM 1000-60.038 B

FIELD VS ALTITUDE FOR CH. 4 HELIX AND TEST DIPOLE

AT 182° TEST SITE

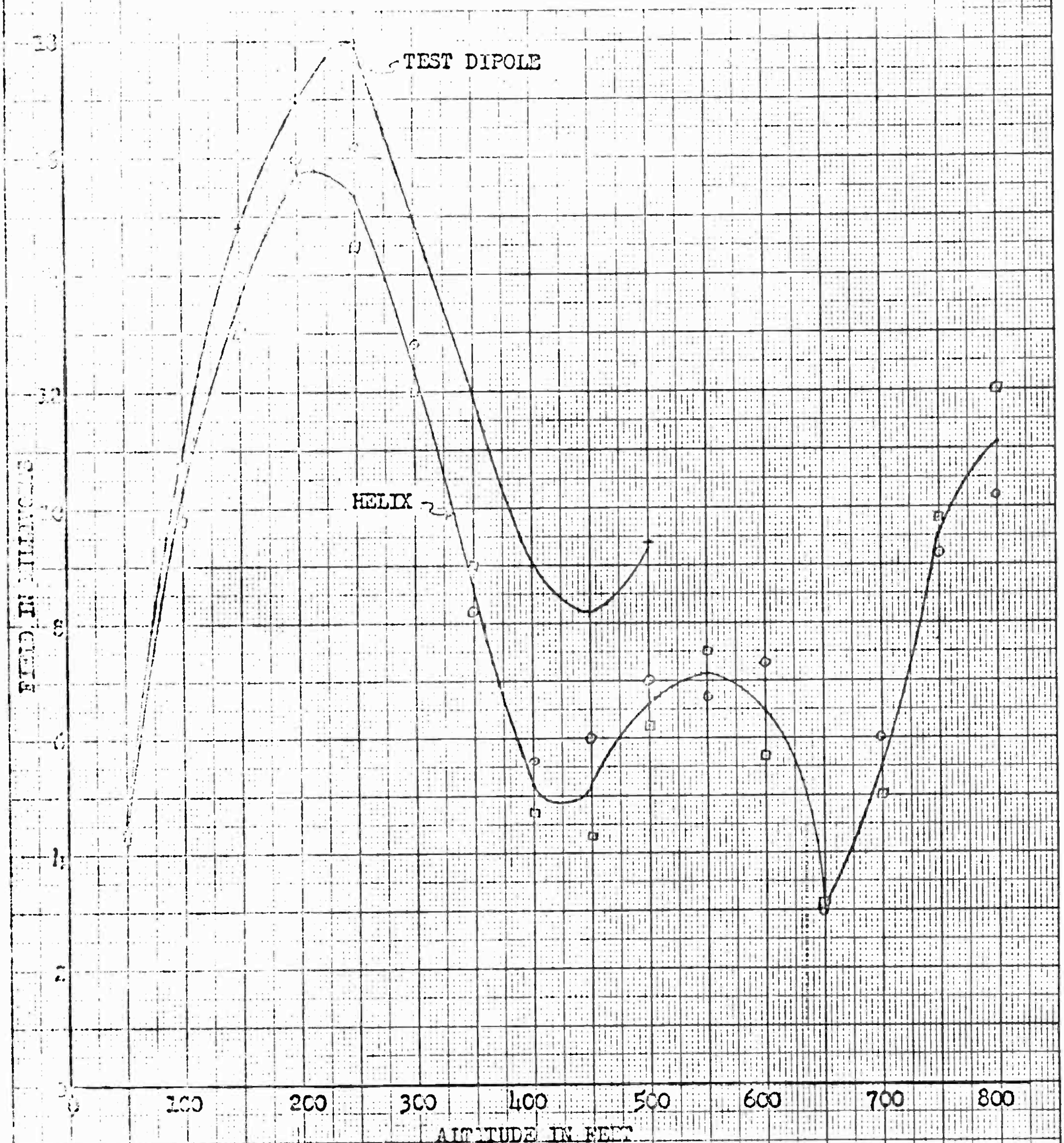


Fig. 15

NOTE:
FROM DATA TAKEN MANUALLY ON 11/21/60

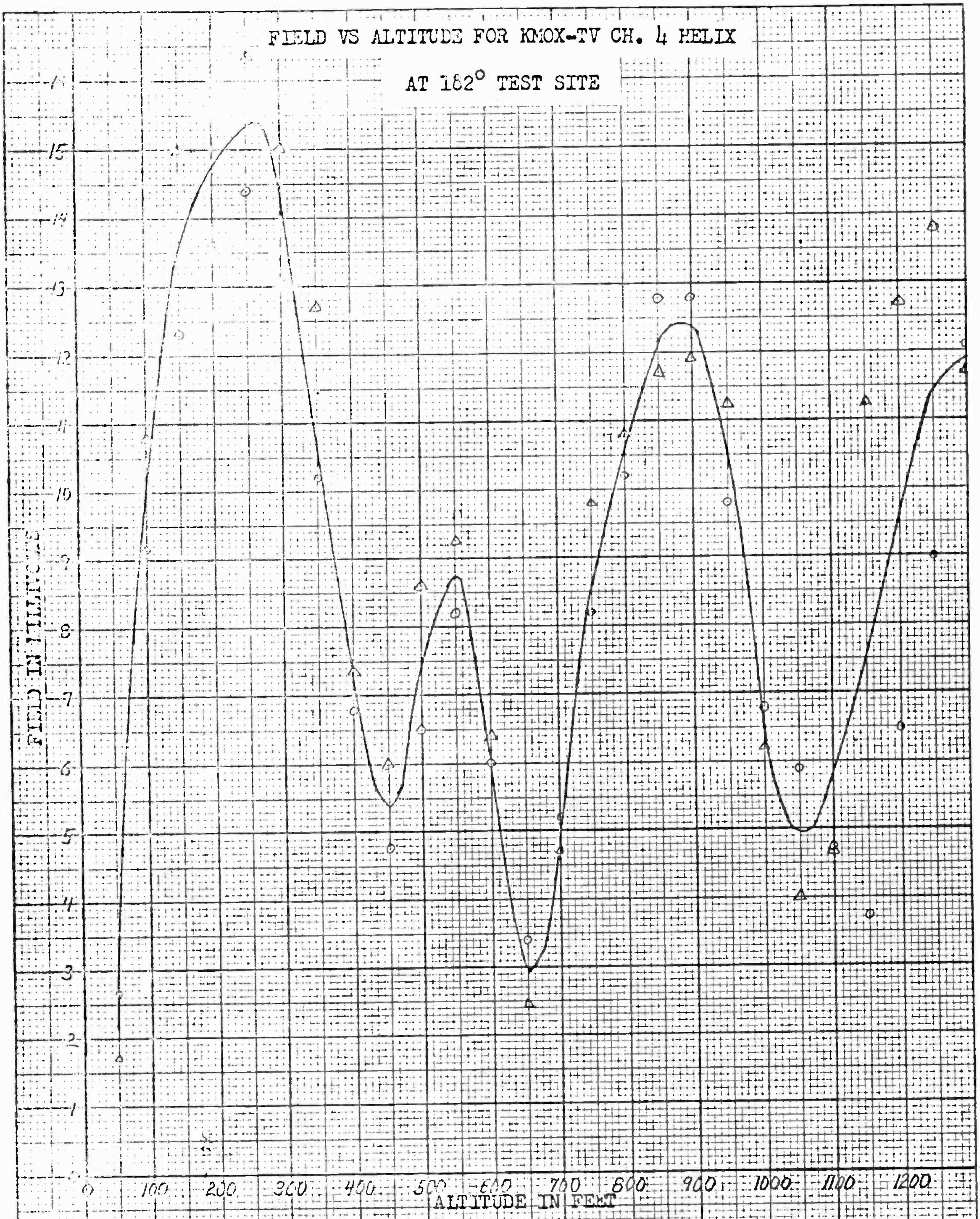
ANDREW ALFORD CONSULTING ENGINEERS

DWG. NO. A14610-5005A

FIG. G.C. DATE 11/30/60

FIELD VS ALTITUDE FOR KMOX-TV CH. 4 HELIX

AT 182° TEST SITE



NOTE:
FROM RECORDER TAPES TAKEN 11/21/60

Fig. 16

ANDREW ALFORD CONSULTING ENGINEERS

DR. BY G.C.

DATE 12/15/60

TITLE

DWG. NO. A11610-5007A

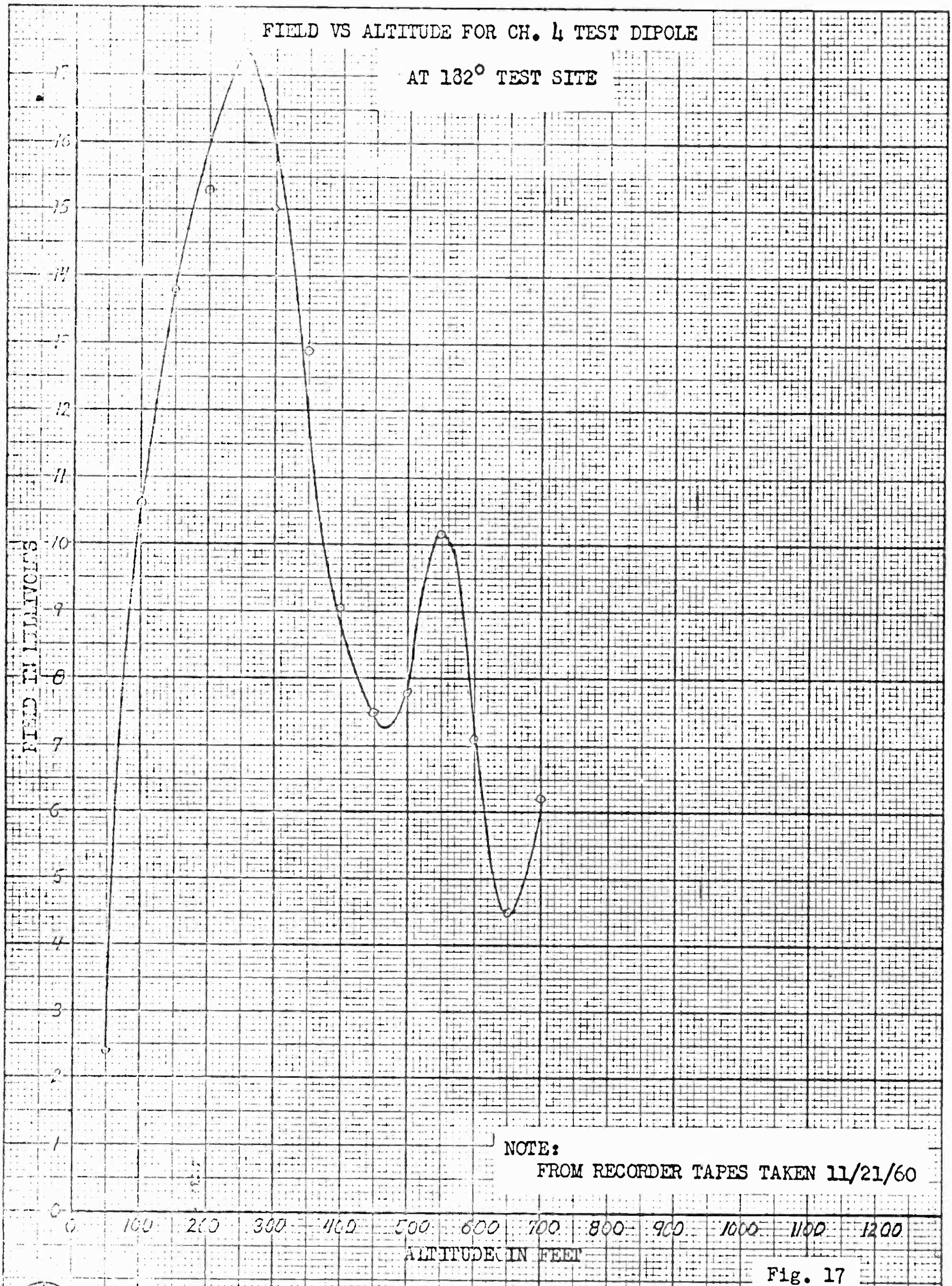


Fig. 17

ANDREW ALFORD CONSULTING ENGINEERS

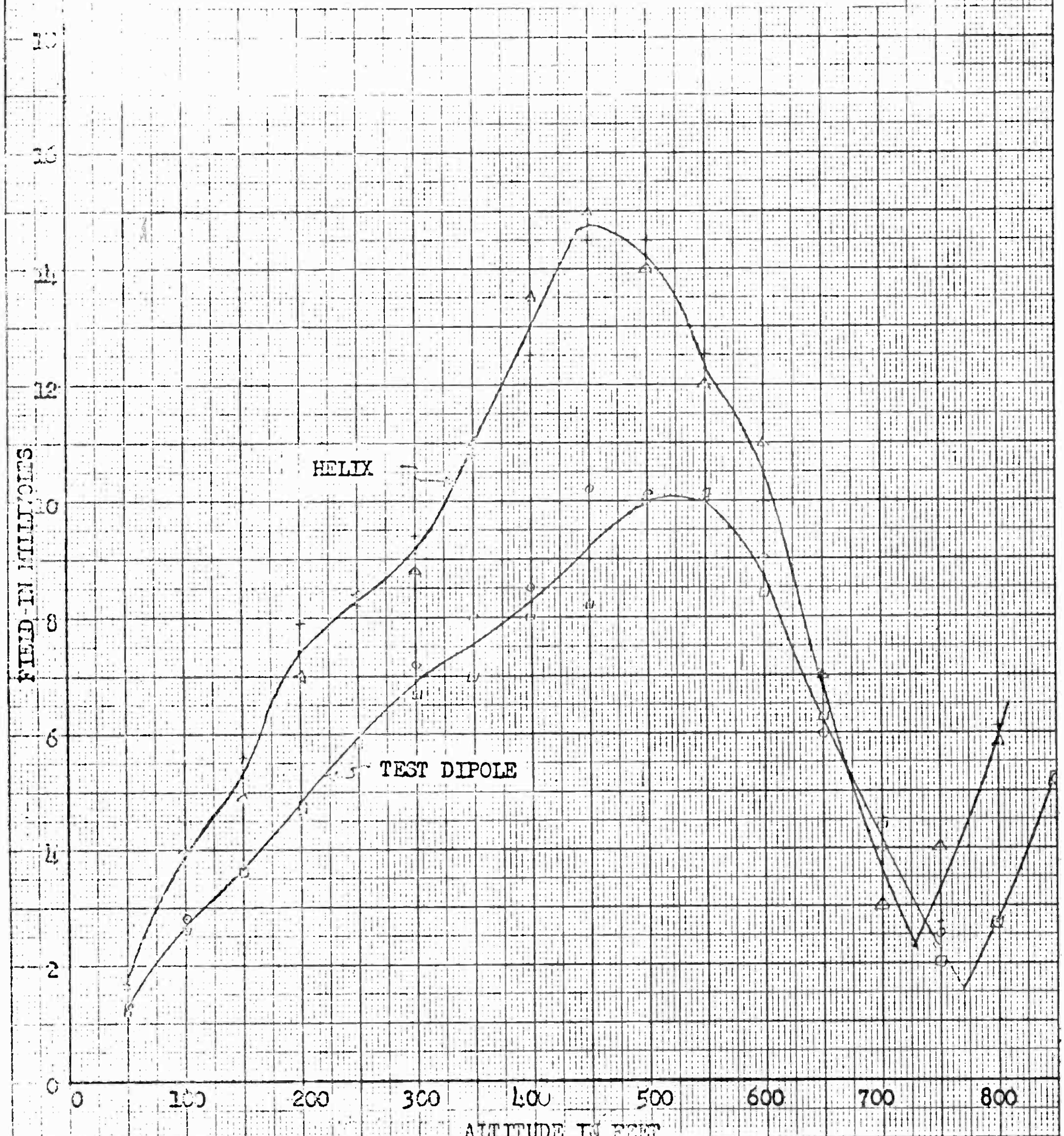
DR. BY G.C.

DATE 12/15/60

TITLE

DWG. NO. A14610-5008A

FIELD VS ALTITUDE FOR CH. 4 HELIX AND TEST DIPOLE AT 346° TEST SITE



NOTE:
FROM DATA TAKEN MANUALLY ON 11/20/60

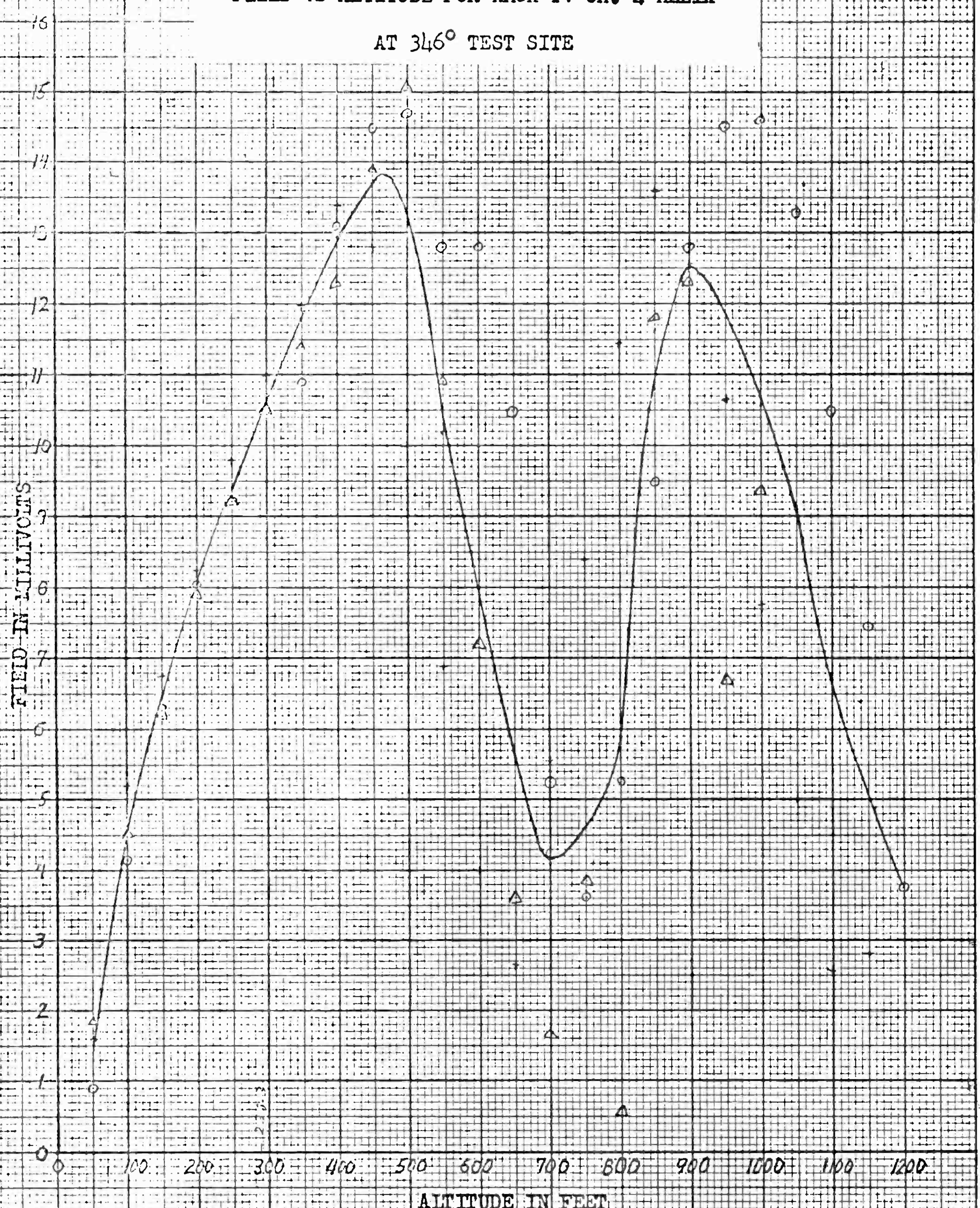
ANDREW ALFORD CONSULTING ENGINEERS

Fig. 18

DWG. NO. A14610-5009A

FIG. G.C. DATE 11/30/60

FIELD VS ALTITUDE FOR KMOX-TV CH. 4 HELIX AT 346° TEST SITE



NOTE:
FROM RECORDER TAPES TAKEN ON 11/20/60

Fig. 19

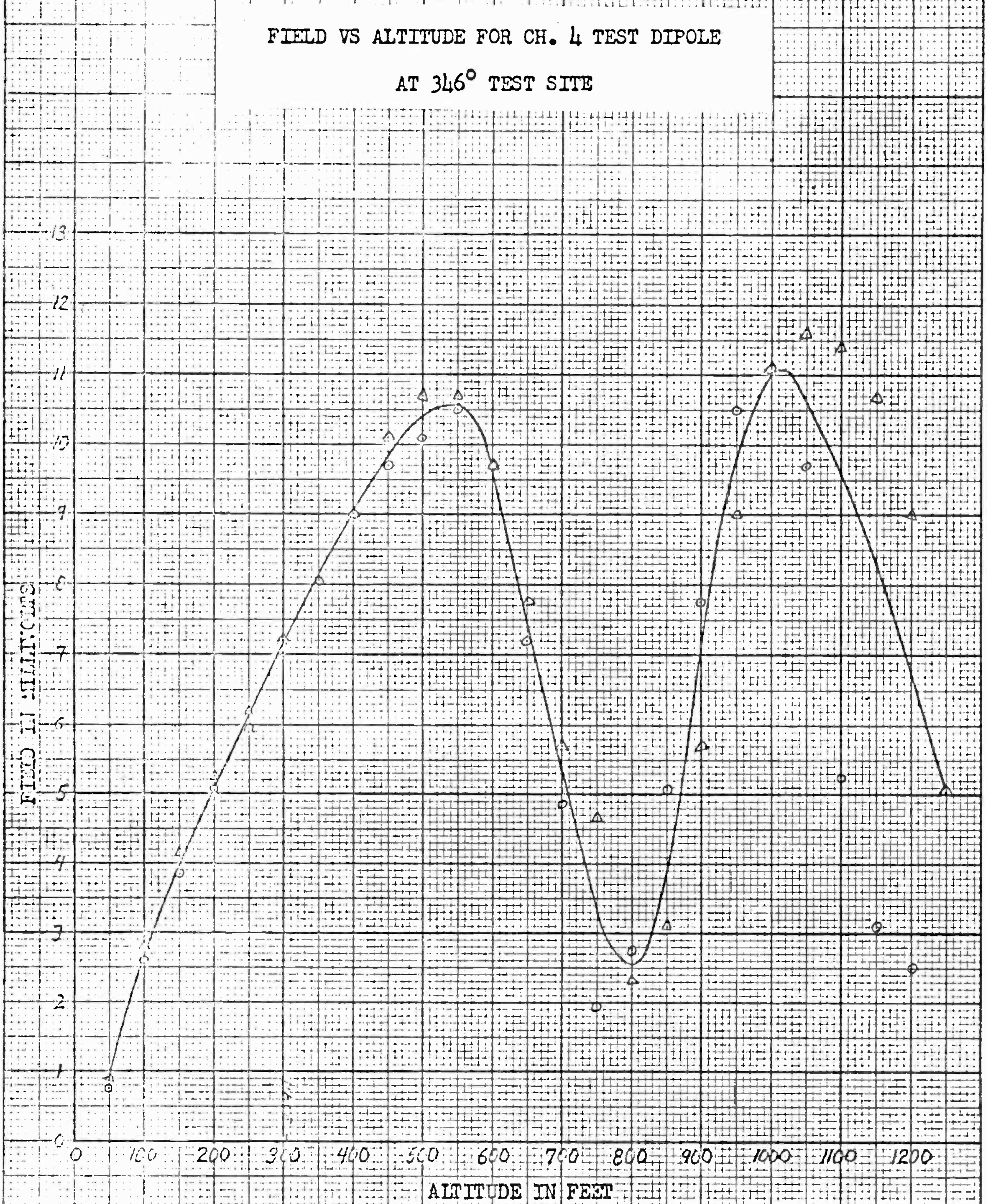
ANDREW ALFORD CONSULTING ENGINEERS

DR. BY G.C.

DATE 12/16/60

TITLE

DWG. NO. A14610-5010A



NOTE:
FROM RECORDER TAPES TAKEN ON 11/20/60

Fig. 20

ANDREW ALFORD CONSULTING ENGINEERS DR. BY G.C. DATE 12/16/60 TITLE DWG. NO. A14610-5011A

AACE FORM 1000-60.038 B

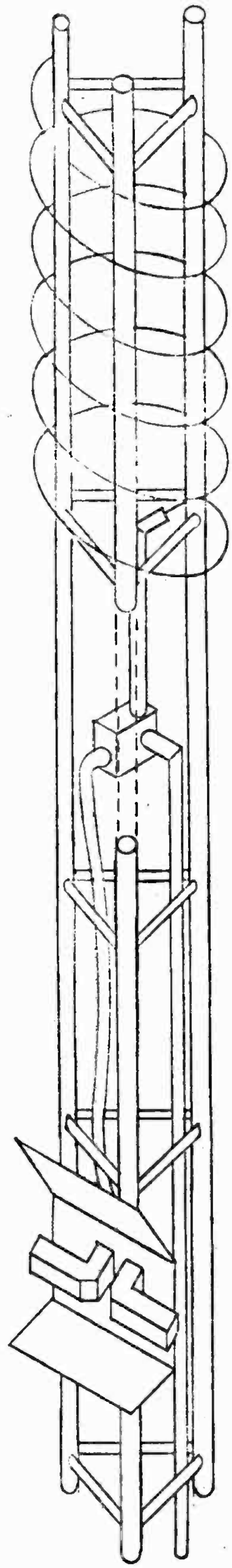


Figure 22

RESULTS OF GAIN CALCULATIONS BASED ON DATA TAKEN AT KMOX-TV

11/16/60-11/23/60

PATTERN USED FOR GAIN CALCULATION	COMPUTED RMS GAIN			AVG. GAIN
	44°	182°	346°	
PATTERN TAKEN FROM HELICOPTER ON 11/21/60 AT 3500 FT. RADIUS.	4.10	7.49	5.62	5.74
PATTERN TAKEN FROM HELICOPTER ON 11/23/60 AT 2.4 - 2.5 MILE RADIUS. (AVG. OF 3 RUNS)	2.85	6.78	6.37	5.33
PATTERN TAKEN AT EARLIER KMOX-TV INVESTIGATION AT 2.4 - 2.5 MILE RADIUS. (AVG. OF 2 RUNS)	3.90	3.90	5.78	4.53
PATTERN TAKEN BY GENERAL ELECTRIC OF THEIR SCALE MODEL OF THE KMOX-TV ANTENNA ON 12/13/60. (AVG. OF 4 RUNS)	4.67	3.69	5.34	4.57
AVERAGE COMPUTED RMS GAIN	3.88	5.46	5.78	5.04

Fig. 24

"B" MODIFICATION: LOWEST ROW, AVG. COMPUTED GAIN, ADDED, GAIN ENTRIES IN G. E. SCALE MODEL AT 44° and 182° INTERCHANGED.

A14610-5014B

G.C. 12/21/60

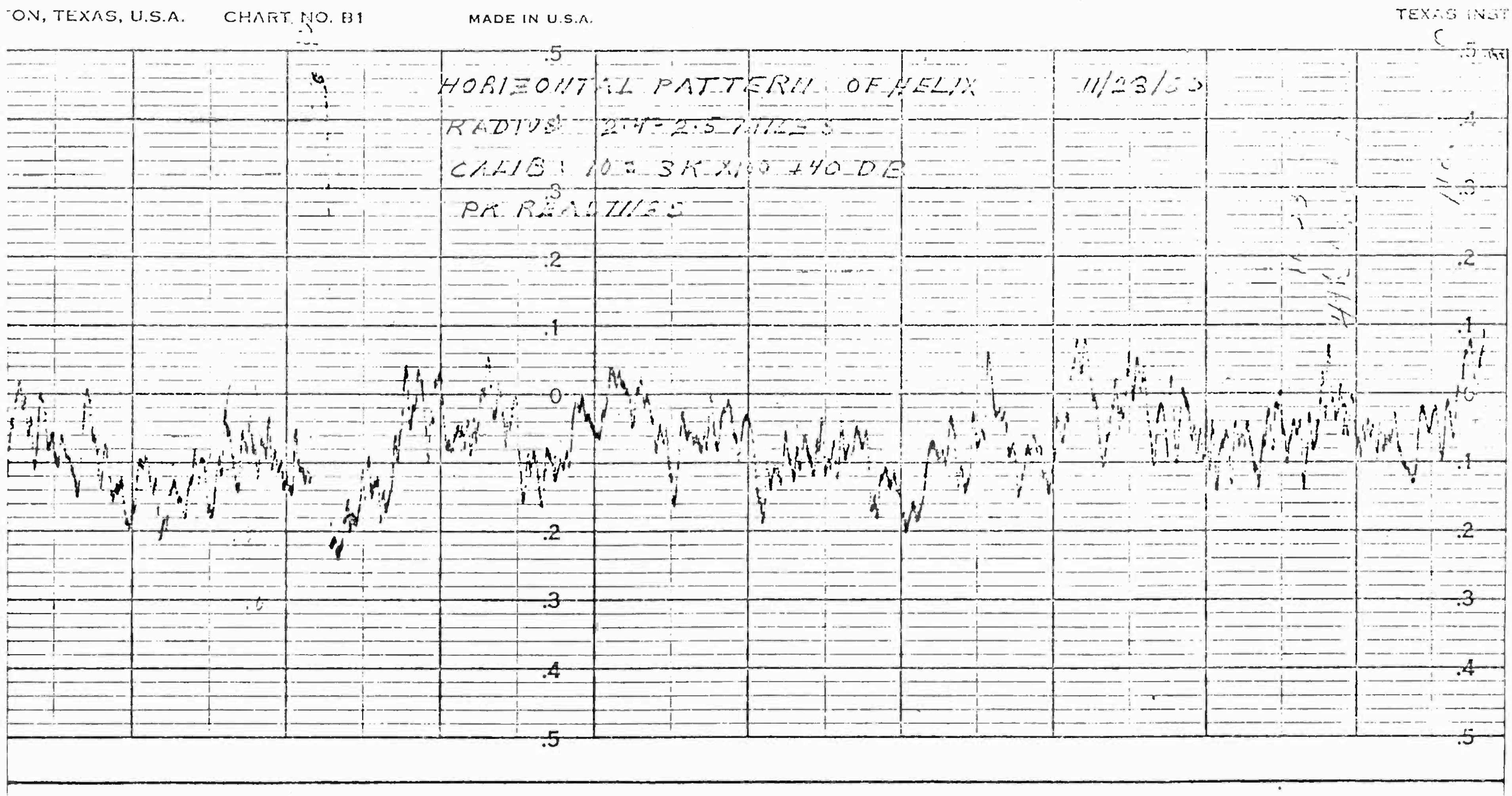

ON, TEXAS, U.S.A.
CHART NO. B1
MADE IN U.S.A.
TEXAS INST
HORIZONTAL PATTERN OF HELIX
RADIUS
PK. READINGS
.5
.4
.3
.2
.1
0

Figure 25

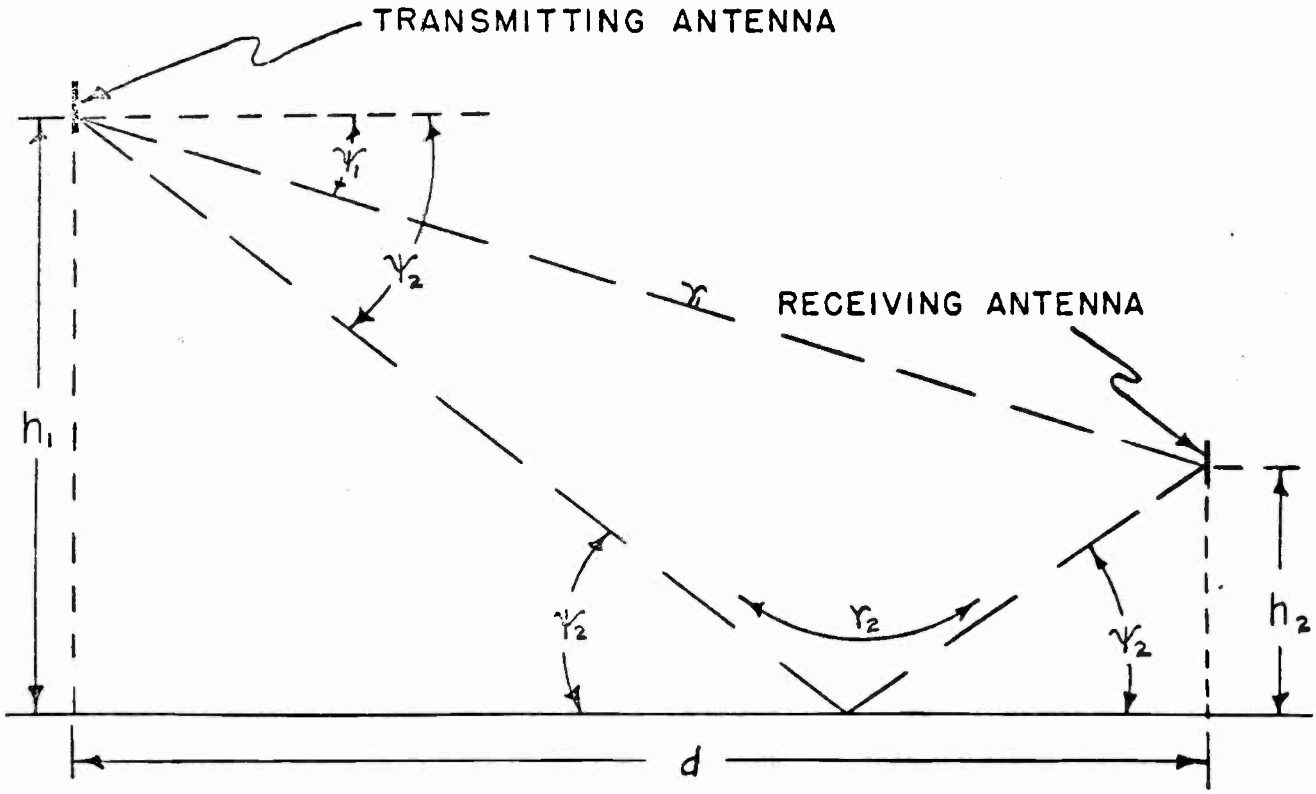


Figure 29

A 14610 - 5032

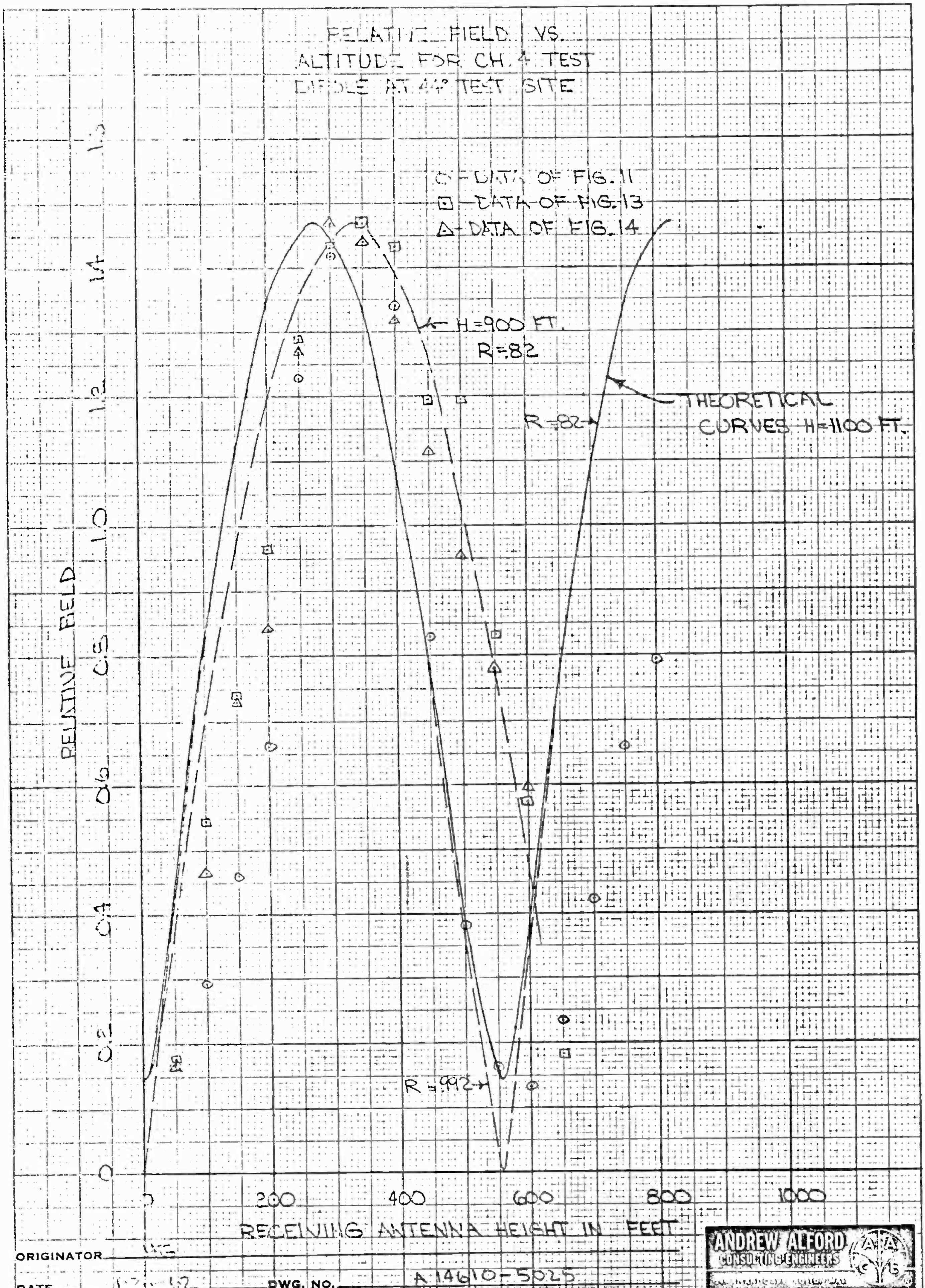
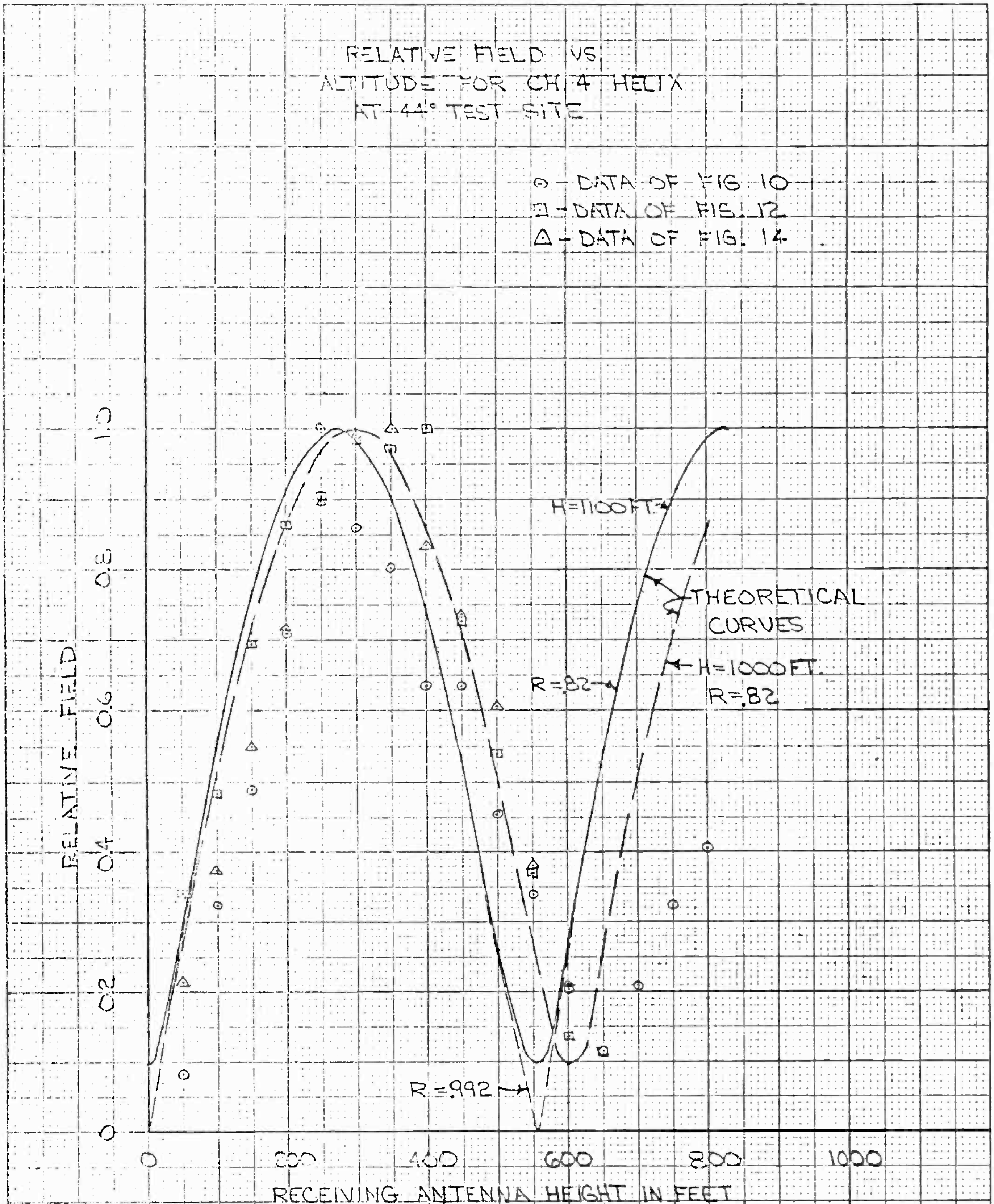

RELATIVE FIELD VS.
ALTITUDE FOR CH. 4 TEST
DIPOLE AT 44° TEST SITE
⊙ - DATA OF FIG. 11
⊡ - DATA OF FIG. 13
△ - DATA OF FIG. 14
H=900 FT.
R=.82
THEORETICAL
CURVES H=1100 FT.
R=.82
R=.992
RELATIVE FIELD
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
0
200
400
600
800
1000
RECEIVING ANTENNA HEIGHT IN FEET
ORIGINATOR
DATE
DWG. NO.
A 14610-5025
ANDREW ALFORD
CONSULTING ENGINEERS
10 X 10 PER HALF INCH
BOSTON 15, MASS.
MADE IN U. S. A.
AACE 1000-60.038

Figure 30A



ORIGINATOR JFG

DATE 1-2...-62 DWG. NO. A 1460-5024

Figure 30B

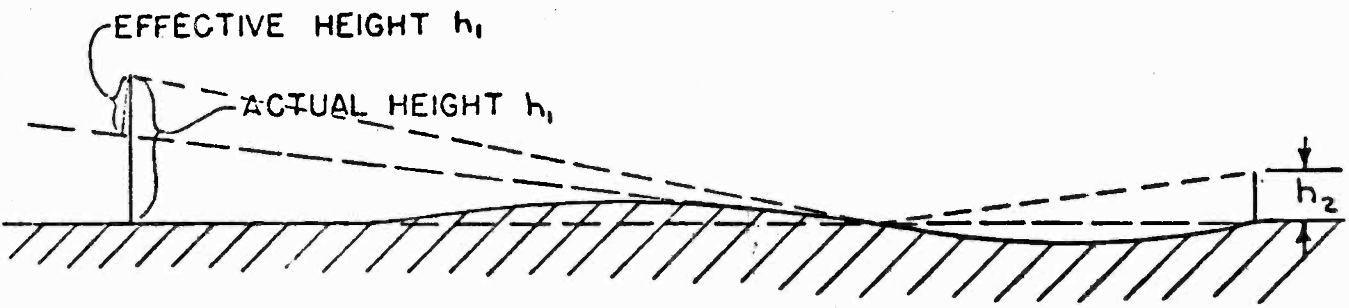


Figure 30C

A 14610-5033

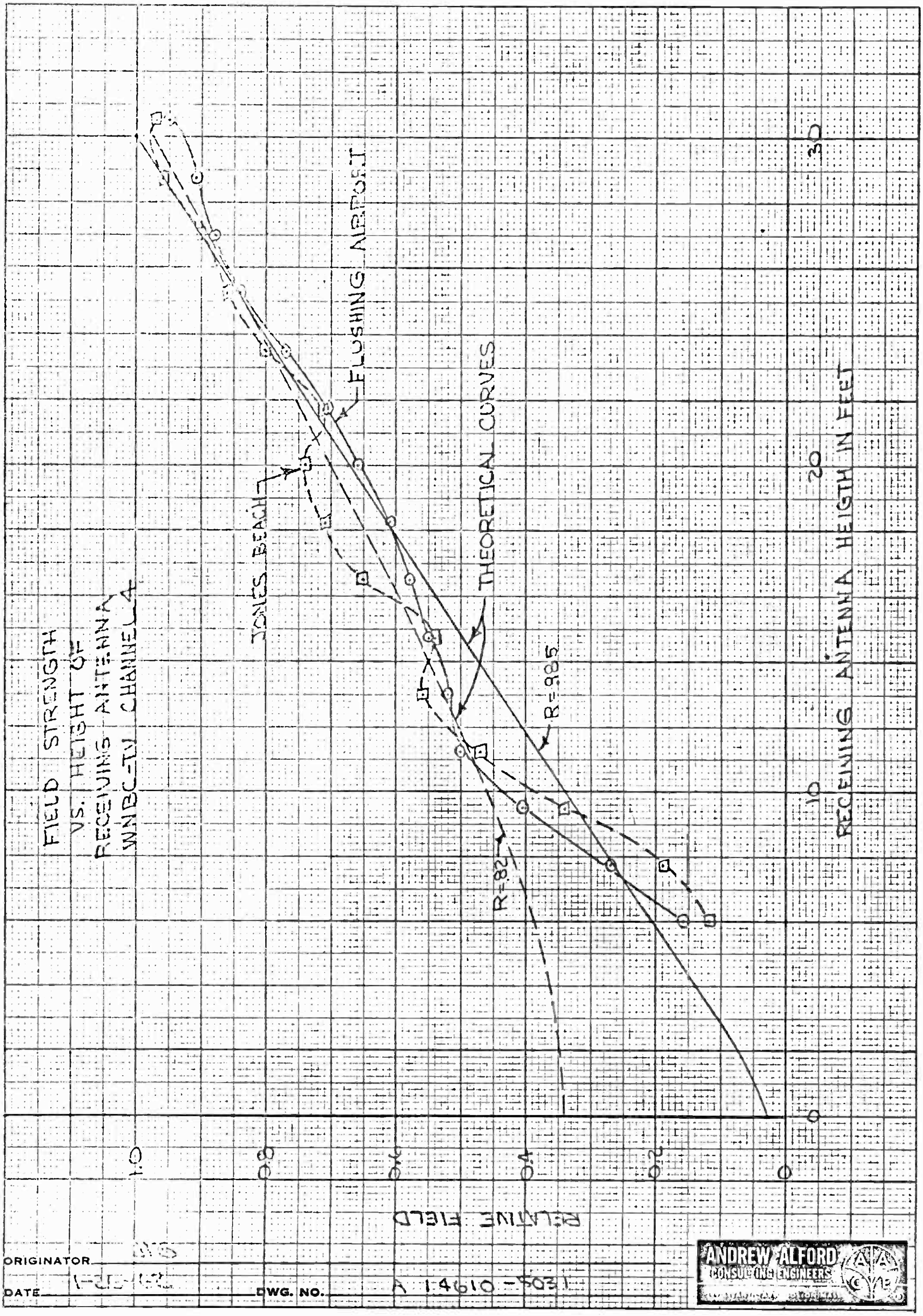

FIELD STRENGTH
VS. HEIGHT OF
RECEIVING ANTENNA
WNBC-TV CHANNEL 4
FLUSHING AIRPORT
JONES BEACH
THEORETICAL CURVES
R=.985
R=.82
RECEIVING ANTENNA HEIGTH IN FEET
RELATIVE FIELD
0
10
20
30
0
.2
.4
.6
.8
1.0
ORIGINATOR
DATE
DWG. NO. A 14610-503
ANDREW ALFORD
CONSULTING ENGINEERS

Figure 31

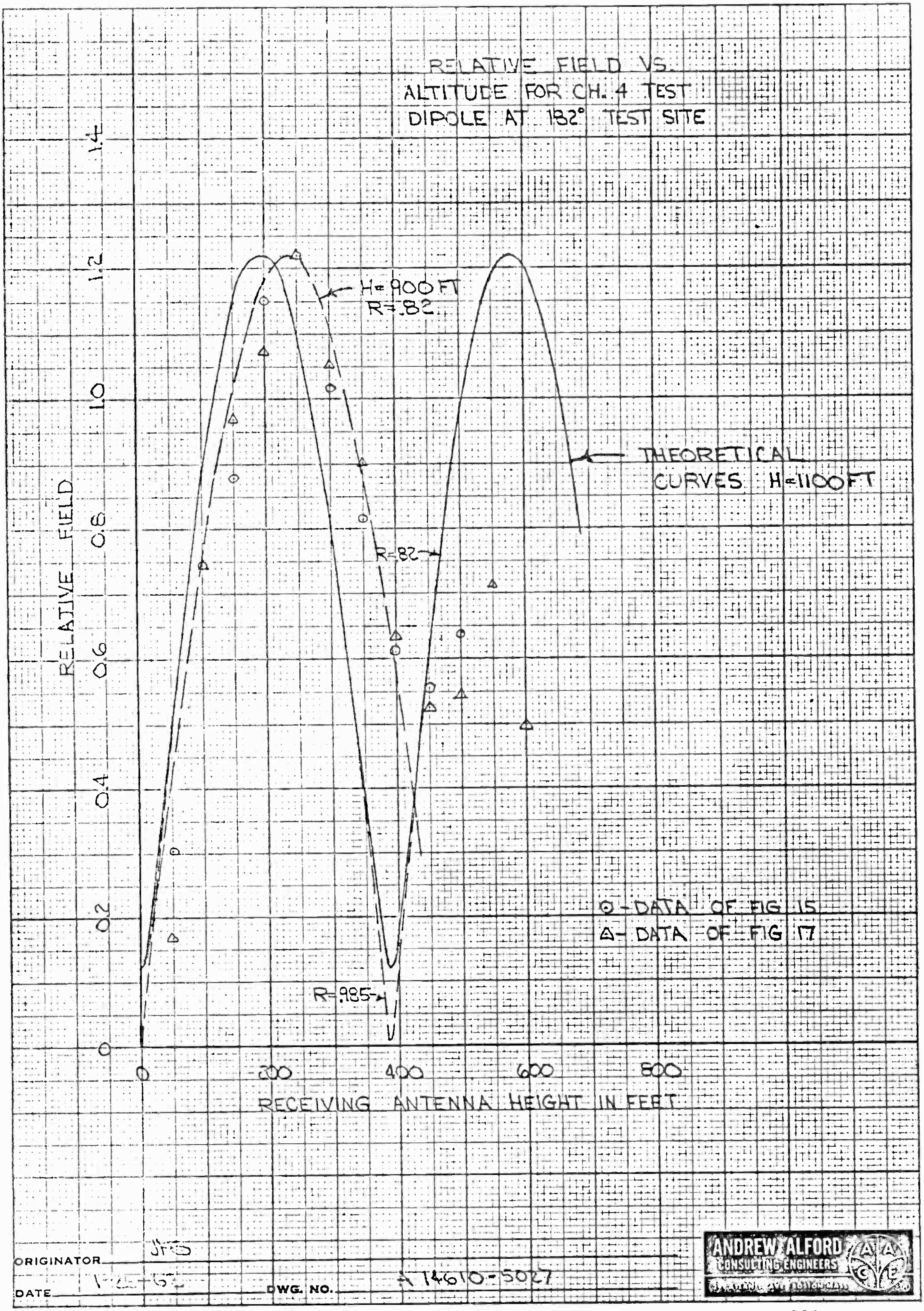

RELATIVE FIELD VS.
ALTITUDE FOR CH. 4 TEST
DIPOLE AT 182° TEST SITE
RELATIVE FIELD
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
H=900 FT
R=.82
THEORETICAL
CURVES H=1100FT
R=.82
R=.985
⊙ - DATA OF FIG 15
Δ - DATA OF FIG 17
0
200
400
600
800
RECEIVING ANTENNA HEIGHT IN FEET
ORIGINATOR
DATE
DWG. NO.
A 14610-5027
ANDREW ALFORD
CONSULTING ENGINEERS

Figure 32A

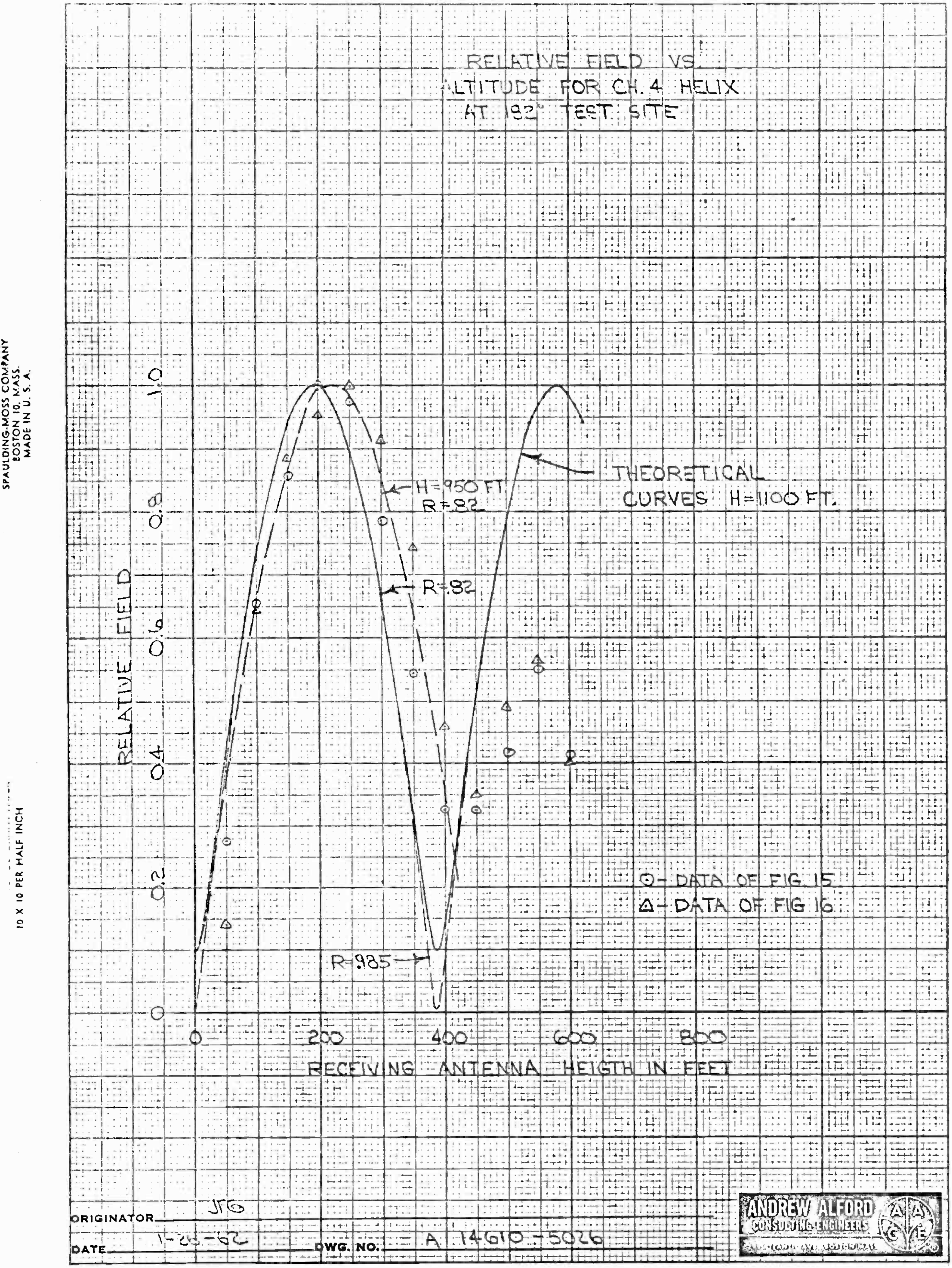

RELATIVE FIELD VS
ALTITUDE FOR CH. 4 HELIX
AT 192' TEST SITE
RELATIVE FIELD
1.0
0.8
0.6
0.4
0.2
0
0
200
400
600
800
RECEIVING ANTENNA HEIGTH IN FEET
H=950 FT
R=.82
R=.82
R=.985
THEORETICAL
CURVES H=1100 FT.
⊙ - DATA OF FIG 15
△ - DATA OF FIG 16
ORIGINATOR JTG
DATE 1-23-62
DWG. NO. A 14610-5026
ANDREW ALFORD
CONSULTING ENGINEERS
SPAULDING-MOSS COMPANY
BOSTON 10, MASS.
MADE IN U. S. A.
10 X 10 PER HALF INCH

Figure 32B

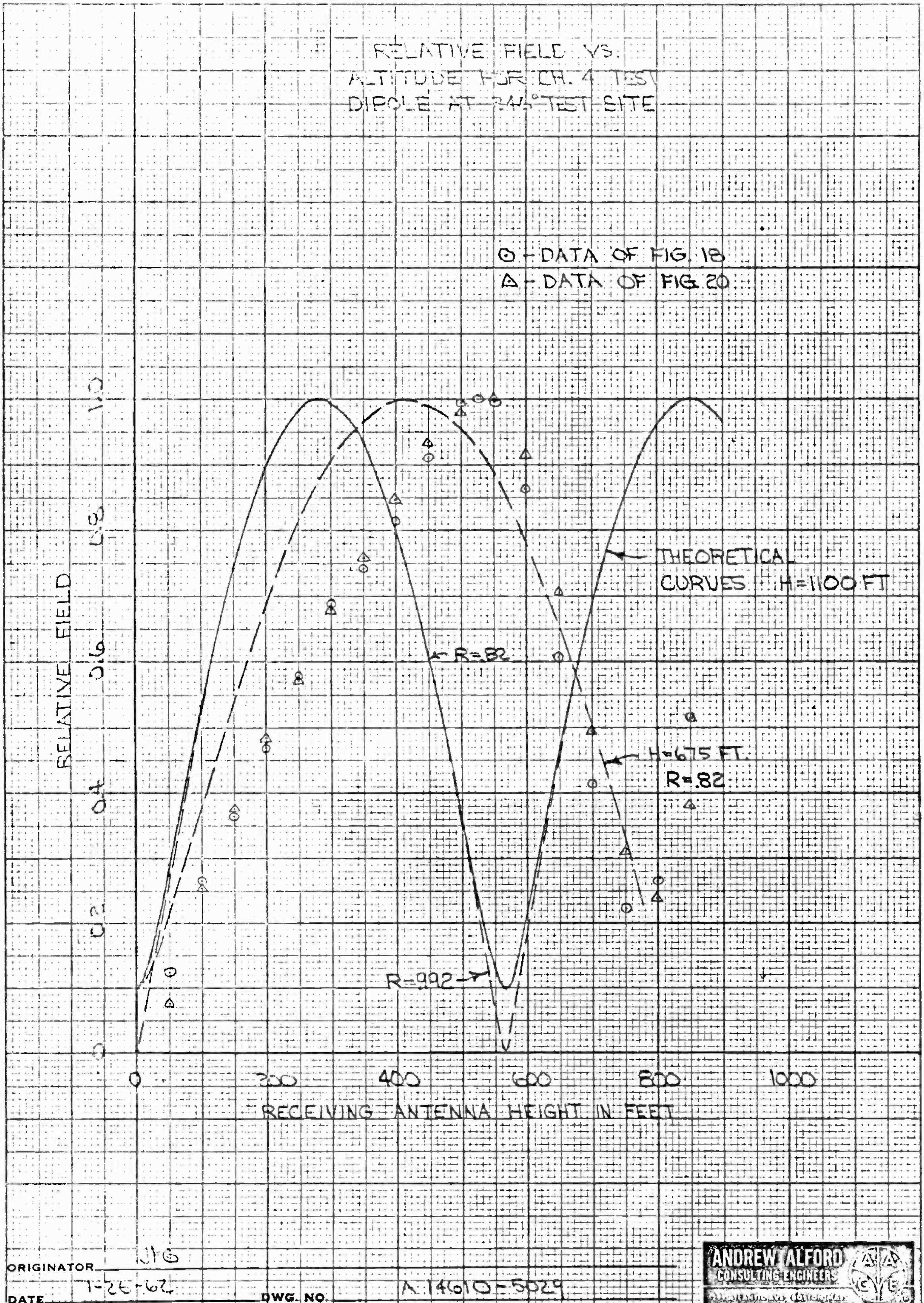
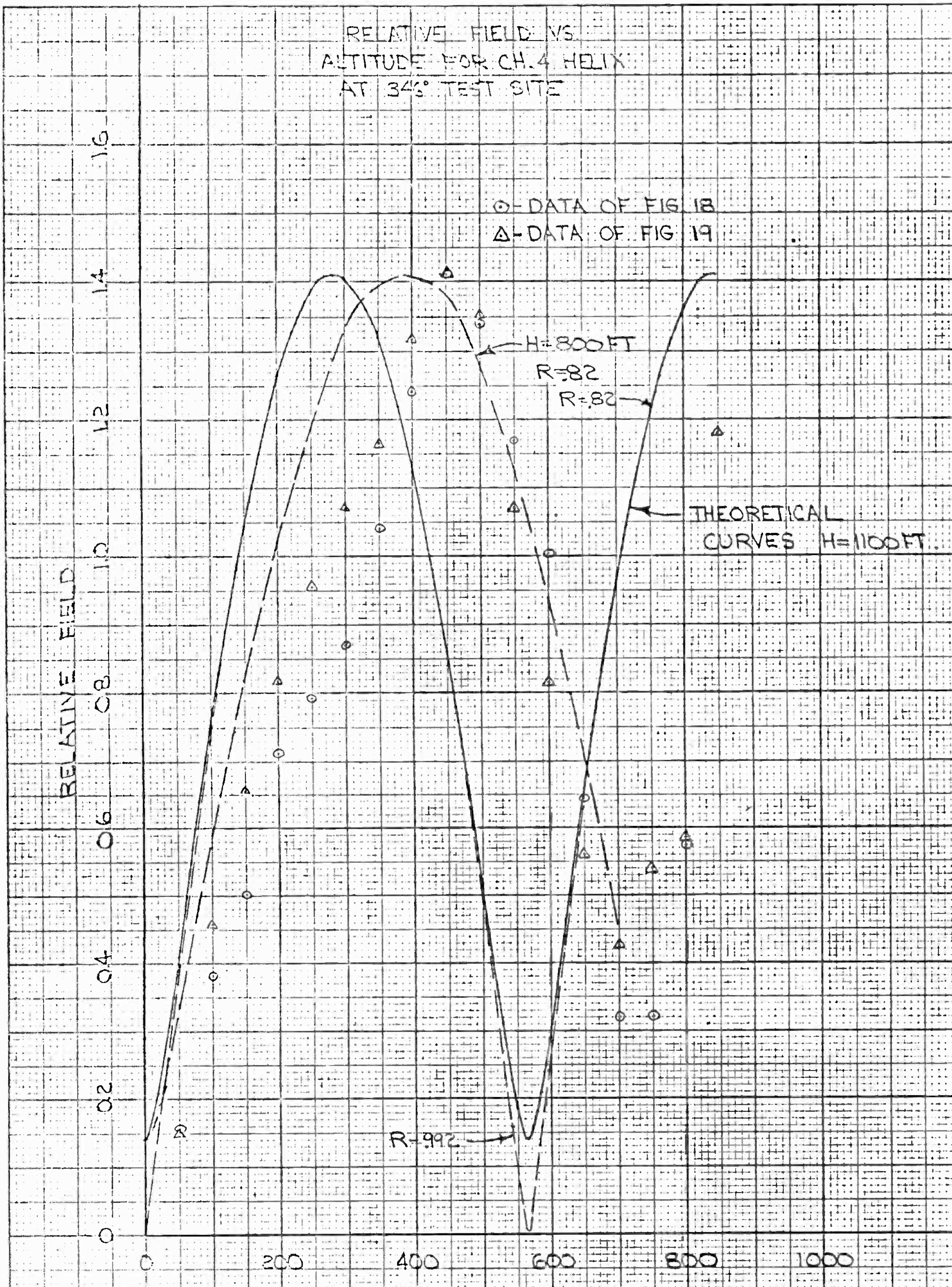

RELATIVE FIELD VS.
ALTITUDE FOR CH. 4 TEST
DIPOLE AT 244° TEST SITE
⊙ - DATA OF FIG. 18
△ - DATA OF FIG. 20
THEORETICAL
CURVES H=1100 FT
R=.82
H=675 FT.
R=.82
R=.992
RELATIVE FIELD
0
0.2
0.4
0.6
0.8
1.0
0
200
400
600
800
1000
RECEIVING ANTENNA HEIGHT IN FEET
ORIGINATOR JIG
DATE 1-26-62
DWG. NO. A 14610-5029
ANDREW ALFORD
CONSULTING ENGINEERS

Figure 33A



ORIGINATOR JTG

DATE 4-26-62

DWG. NO. A 14610-5026

ANDREW ALFORD CONSULTING ENGINEERS

10 X 10 PER HALF INCH

BOSTON 10, MASS. MADE IN U. S. A.

Figure 33B

PROBLEMS ENCOUNTERED IN THE CONTROL OF HEAT AND DUST ON TRANSMITTER PLANTS

By

Albin R. Hillstrom
Chief Engineer
KOOL AM-FM-TV
Phoenix, Arizona

For

National Association of Broadcasters
Chicago, Illinois
April 4, 1962

PROBLEMS ENCOUNTERED IN THE CONTROL OF HEAT AND DUST ON TRANSMITTER PLANTS

The weather in Phoenix, Arizona in the winter time is sunny, pleasantly warm, or in fact perfect. However, in the few summer months it is very hot and dry. The temperature reaches up to 118° F. It stays hot and dry throughout the summer, but due to air conditioning, people live in cool comfort all year around. Transmitters also are intended to operate in somewhat cooler temperatures.

When planning a new transmitter installation in the Spring of 1961, therefore presented problems peculiar to our hot and dry summer, namely:

1. Unusually high ambient temperatures.
2. Fine dust conditions in the summer months.
3. Plus our existing building with a low ceiling, restricting ductwork and transmission line placement.

The purpose and intention of this paper is to describe how we chose to solve these problems, by the use of refrigeration, using extra care in filitering, and carefully designing the ductwork.

The installation is located on South Mountain, a mountain that the Phoenix television stations use, 8 miles from Phoenix, 2,700 ft. high.

The air system herein described is on a General Electric TT 46A1 35 kw television transmitter, consisting of a 10 kw driver (TT-32B) and 35 kw amplifier (TT 14A). All of it is air cooled using eight 7007 tubes in the final stages. (3 in each final and 1 in each driver.) In designing the transmitter, the manufacturer provides the necessary internal ducts in the cubicles and the blowers required to affect proper cooling under normal conditions. They supply you with the dimensions, air requirements for each cubicle, and a sample ductwork layout between the blowers and the cubicles and the exhaust system. However, since each individual installation is different, it is left up the installer to provide the final ductwork and exhaust system. The air system layout warrants the most careful initial planning. Ductwork installation is expensive and if not done right to begin with it is doubly expensive to correct. The services of a competent air conditioning and heating engineer should be acquired, but the chief engineer ought to be very familiar with the air system requirements, because the average air conditioning and heating contractor is not well acquainted with the type of air handling required.

Due to the high ambient temperature in our area, increased cooling was desired. The manufacturers specifications on maximum operating temperature is 114° with the recommendation that it should be 95° or less 95% of the time. The transmitter undoubtly would operate without increased cooling, but the thought of operating tubes and components at, near or over their maximum ratings for extended periods is not very comforting.

Four possible methods of additional cooling were considered, namely:

(a) Increasing the air flow (discarded because of the limited installation space for ductwork.

(b) Using evaporative cooling (manufactures high humidity).

(c) Partial use of refrigeration.

(d) Complete refrigeration.

After studying the installation and operating cost verses calculated savings in tube and component cost, air time and peace of mind, we decided upon complete refrigeration of the transmitter. Also it could be made relatively simple.

The total air requirements to the transmitter is 7100 cfm. It was desired to lower the temperature of this volume of air by 20° F. when the outside temperature was 115° F. Using the formula; 1BTU will raise or lower 56 CFH of air 1° F. therefore:

SLIDE 1. (BTU Figures)

60 BTU cooling per 1° per 56 CFM =

1200 BTU cooling per 20° per 56 CFM =

152,160 BTU cooling per 20° per 7100 =

152,160 BTU = 12.7 tons

The result being about 13 tons of refrigeration. Instead of using one central refrigeration unit, we decided to use 3 - 5 ton units so they could be step controlled and overheating would not result from the failure of one or even two units. (Air conditioning always seems to fail on the hottest days.)

SLIDE 2. (Refrigeration Ratings) The refrigeration units that we used are rated as follows:

63,500 BTU at 95° ambient temperature

58,000 BTU at 110° ambient temperature

56,000 BTU at 115° ambient temperature

The three units used put out 168,000 BTU at 115° ambient temperature lowering the temperature of 7100 CFM of air 22° F. Note that the efficiency of the refrigeration drops 12% at 115° as compared to 95° F. The refrigeration units are conventional air cooled, except the chill coils were stripped of their blowers. The transmitter blowers do all the air moving. The optimum air through the chill coils is 6,000 CFM.

SLIDE 3. (Equipment layout) The complete plant includes a 5 kilowatt RCA FM transmitter and 2 kilowatt RCA auxiliary TV transmitter. Both of these transmitters also use refrigerated air.

The main transmiiter room size is 30' by 20' with only a 9' 2" ceiling.

SLIDE 4. (Front of transmitter) The transmitter is in line with an air tight wall built around the front.

SLIDE 5. (Back of transmitter) The entire back area 30' by 11' is sealed air tight and becomes the plenum chamber, henceforth, I'll label it the plenum room. All the external components and sideband filter are contained in this room. The blowers are mounted in an air tight room within the plenum room.

SLIDE 6. (Chill Coils) The chill coils are mounted in the outside wall on the opposite end from the blower room.

SLIDE 7. (Compressors) The three compressors are outside 15 feet from the chill coils.

SLIDE 8. (Equipment layout) FIGURE 1. The outside air is drawn through the chill coils (by negative pressure) by the transmitter blowers which continually exhausts the room air via the ducts through the transmitter cubicles and exhaust system back to outside.

SLIDE 9. (Thermostats) The temperature is thermostatically controlled. The inside blower room wall contains four thermostats, one for each compressor and one heat return thermostat. The compressor thermostats are adjusted in steps for 80°, 82° and 84° or any other desired combination.

SLIDE 10. (Equipment layout) If they were all set the same the compressor's would argue to see who would come on and cycle. The blower room temperature then dictates how much refrigeration is needed (depending on the outside air temperature) and turns the compressors on accordingly to keep the temperature between 80° and 84° in the blower room.

When one or two compressors are off, the air through the chilled coil and the hot coil mixes in the plenum room and is at an even temperature when it reaches the blower room. Theoretically, the first compressor starts at 80° outside temperature, 2nd at 89° and third at 97°. But from last summers operation the third came on at 106°, two-thirds cooling was sufficient up to 106° F. A 30° reduction was achieved by running all three compressors when the outside air was 110°.

Triple stage filtering is used in the air stream to trap the fine dust. In front of the chill coils is a 2" fiber glass filter to pre-filter all the air entering the plenum room. The two rectifier cubicles take 500 CFM of air each from the plenum room and each one has an oil bath filter in the door.

SLIDE 11. (Filter wall) The blower room wall contains a Farr Company High Performance filter bank consisting of an oil bath filter followed by a high performance cloth filter to trap contaminent to 2 micron size. Filters to trap contaminents to .05 micron size (which would trap oil smoke, tobacco fumes, etc.) could be used, but we found that these weren't needed in our area.

SLIDE 12. (Picture of ducts) Due to the limited ceiling height in the existing building, input and exhaust ducts had to be very carefully designed to affect the least air resistance, and keep down noise. The input ducts are rectangular with 90° rectangular elbows, equipped with specially designed turning vanes. This type of turning vane is the most effiecient. The turbulance in the round elbow increases the resistance.

SLIDE 13. (Turning elbows, and air straightener) FIGURE 2. Each cubicle air inlet was equipped with a dual air straightener to insure streamline air flow. The cubicles are equipped with a butterfly air interlock and the air flow must be free of turbulance and pulsing.

SLIDE 14. (Picture of Ducts) The 2400 CFM ducts to the 10 kilowatt driver are 16" by 10" reducing in size to 3/4 after it passes the visual cubicle. A damper was installed in the continuing duct so the air to each cubicle could be balanced, the 3700 CFM ducts to the 35 kilowatt are 22" x 14" with the same ratio and damper arrangement. These ducts are made of 22 gauge galvanized steel. Exhaust ducts are round and go through the ceiling to the roof, into a common exhaust duct equipped with a blower capable of exhausting 8,000 CFM. Due to the negative pressure in the plenum room, the cubicle vents were also ducted to the exhaust system, otherwise a partial short circuit path would be open and more than the intended air would pass through these vents. (END OF SLIDES) The exhaust system is also equipped with return ducts to heat the building with the warm air and a return duct to the plenum room to heat the outside air during the winter months. The air return to the plenum room is controlled by the heat thermostat in the blower room set at 70° F. 70° was chosen, so there wouldn't be any chance of unnecessary cooling or heating.

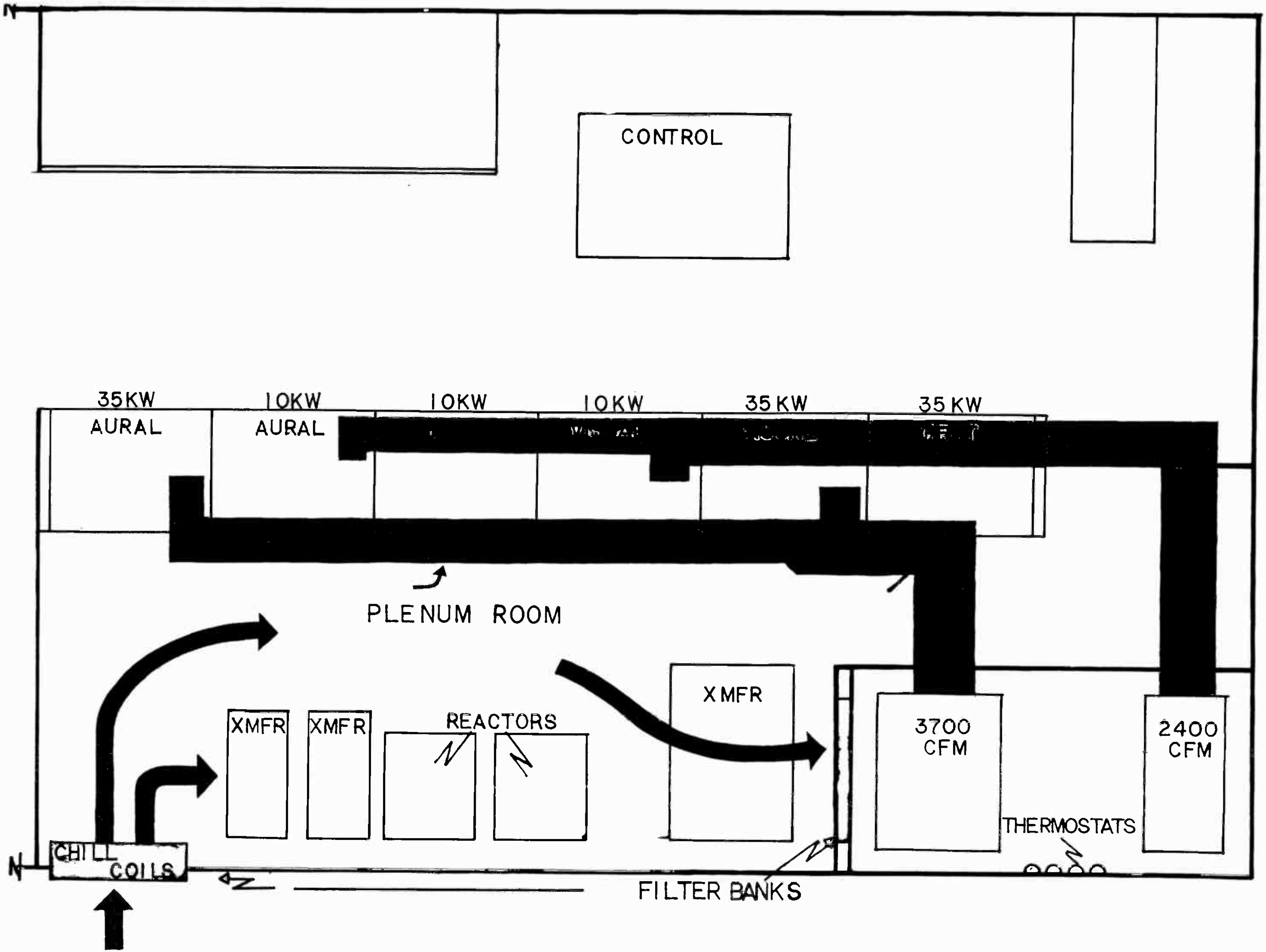
The control system for the refrigeration is interlocked with the transmitter blowers, so the compressors can't come on without air flow. The transmitter operator only has to record the temperatures, otherwise the system operates automatically.

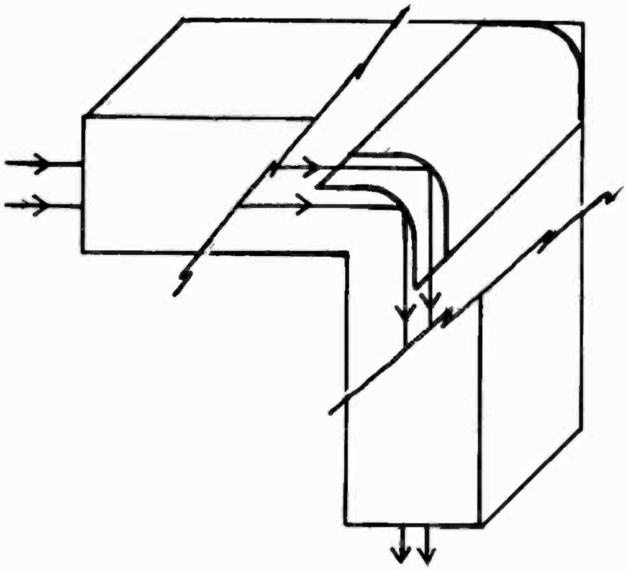
The installation cost was not prohibitive. The idea was turned over to four air conditioning contractors and the bids ranged from $3,000 to $9,000 excluding the refrigeration units. We had available from the old installation two refrigeration units and a third was purchased at $750.00. Allowing $2,250.00 for all the refrigeration, the total cost of the air system was $5,250.00. By conservatively estimating the savings on tube and component life, the refrigeration should be self amortizing.

This plant has been in operation 5,000 hours to date, so I can't give you actual tube life. Besides having a controlled temperature range, another factor that will greatly affect the tube life is that the transmitter operates at 77% of its rated power (driver at 40%).

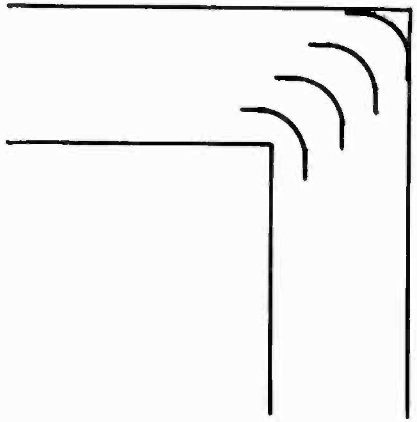
We also use the by-products. Despite low humidity of the desert air during July and August enough condensation takes place that by trapping the water and pumping it into our storage tank we have plenty of water for lavatory and other uses.

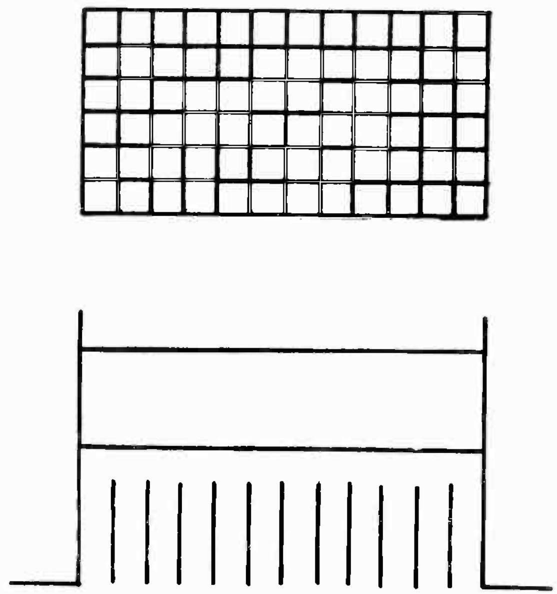
Thank you very much,


CONTROL
35KW
AURAL
10KW
AURAL
10KW
10KW
35 KW
35 KW
PLENUM ROOM
XMFR
XMFR
REACTORS
XMFR
3700
CFM
2400
CFM
THERMOSTATS
CHILL
COILS
FILTER BANKS

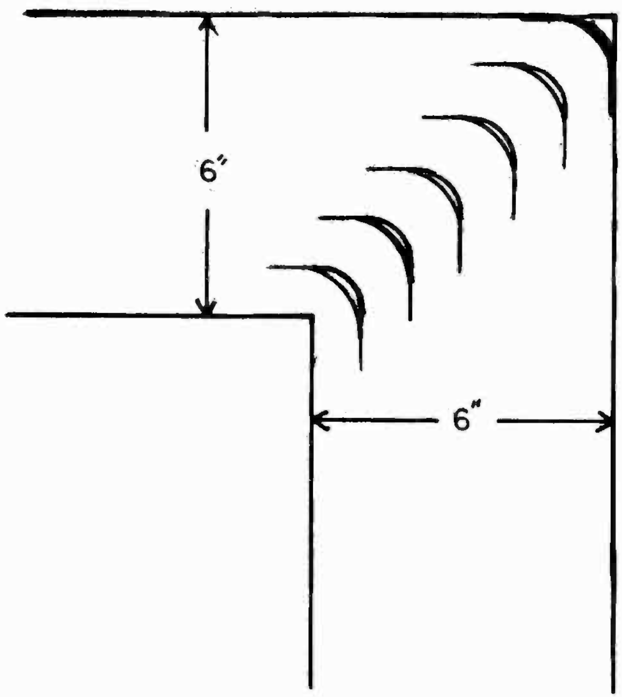


TURNING VANES ARE 1 INCH APART

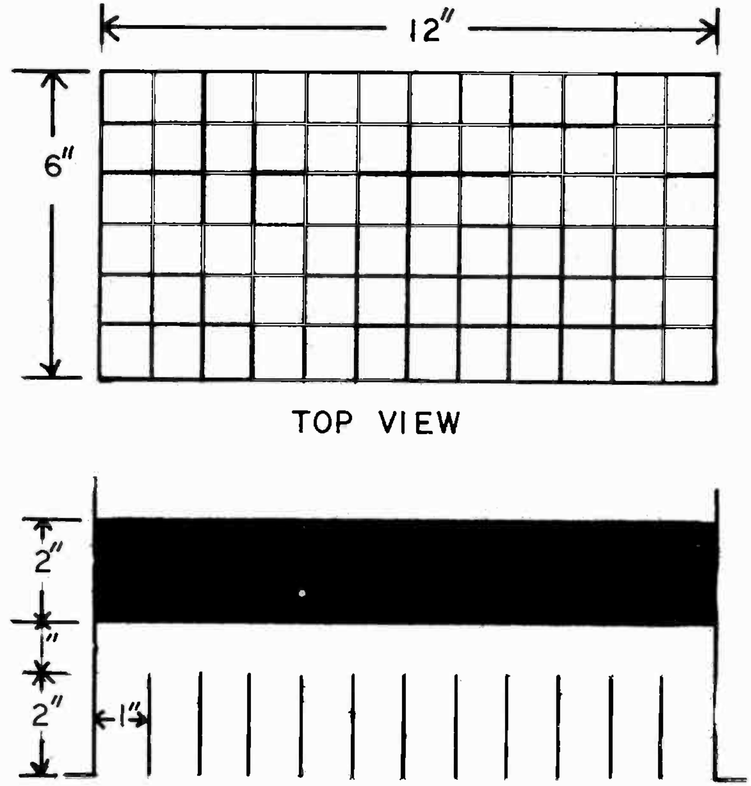




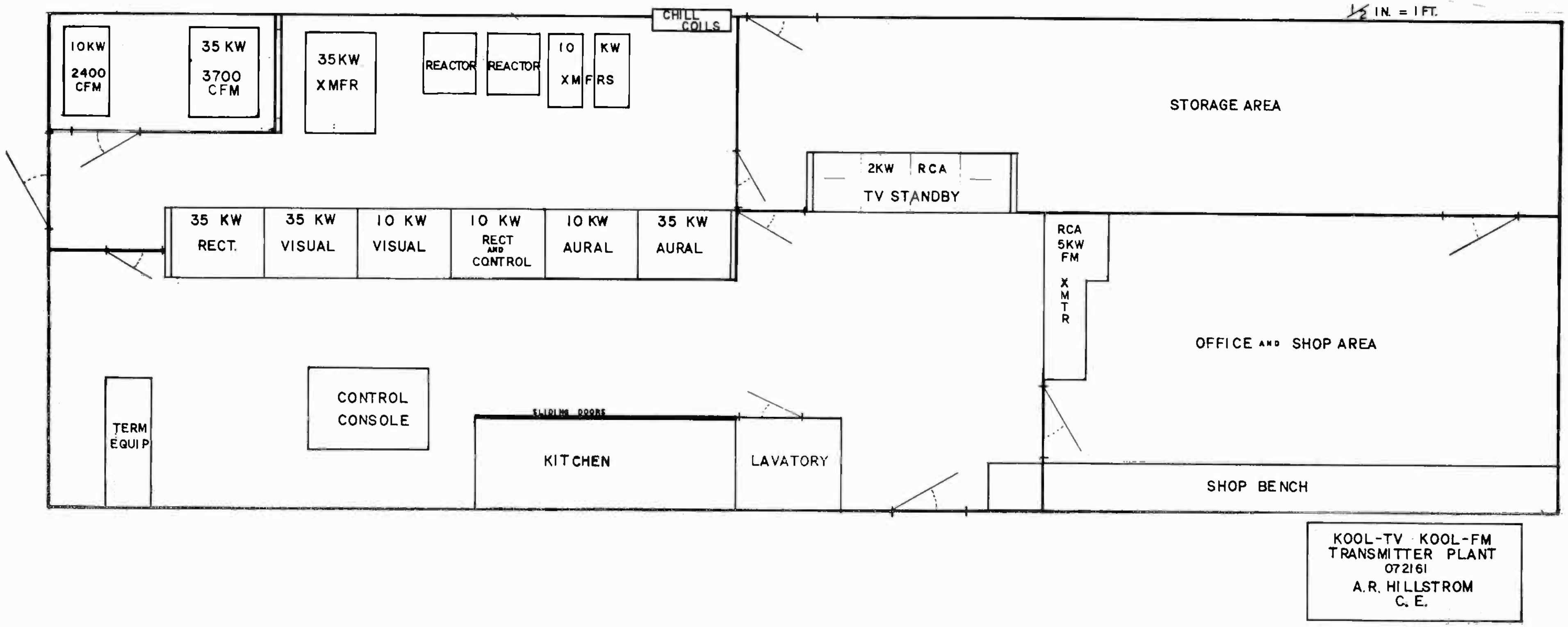
CROSS SECTION AIR STRAIGHTENER



TURNING ELBOW



AIR STRAIGHTENER


1/2 IN. = 1 FT.
10KW
2400
CFM
35 KW
3700
CFM
35KW
XMFR
REACTOR
REACTOR
10
KW
XMFRS
CHILL
COILS
STORAGE AREA
2KW RCA
TV STANDBY
35 KW
RECT.
35 KW
VISUAL
10 KW
VISUAL
10 KW
RECT
AND
CONTROL
10 KW
AURAL
35 KW
AURAL
RCA
5KW
FM
XMTR
OFFICE AND SHOP AREA
TERM
EQUIP
CONTROL
CONSOLE
SLIDING DOORS
KITCHEN
LAVATORY
SHOP BENCH
KOOL-TV KOOL-FM
TRANSMITTER PLANT
072161
A.R. HILLSTROM
C. E.

THE SUCCESSFUL LICENSE LAW FOR TV AND RADIO TECHNICIANS IN THE STATE OF LOUISIANA

J. D. Bloom

WWL-TV
New Orleans, La.

HISTORICAL

When television first began to take hold in the New Orleans area in 1950, the legitimate servicemen and the TV station technician soon realized that the would-be mechanics were undermining the industry. The admen may call it an "image", the lawyer a "viewpoint", but John Q. Public was losing confidence in the new medium because of poor and expensive service work. This was the main reason for many manufacturers establishing their own captive service.

The TV Servicemen's Association in New Orleans, affiliated with the National NATESA, inaugurated a campaign to organize the rest of the state with great success. As more TV stations came on the air in the Mid-50's, more and more servicemen joined the drive on the "night-crawlers", as they were called, to improve the public acceptance of television.

Finally, in 1958, with the joint cooperation of the IBEW station technicians and the TESA chapters, a law was passed in the state legislature requiring the licensing of all persons engaged in radio and TV maintenance and service on home receivers in cities of over 20,000 population. This latter limitation was a sore point as it did not cover the servicemen in the suburbs of the larger cities. This provision was repealed in 1960, now including all radio and TV servicemen in the state. It may be noted that the individual men are licensed, not the shop or shopowner. To my knowledge, Louisiana is the first state to have such a law. South Bend, Indiana, and Buffalo, New York have such laws, but are having the suburban area problems.

OPERATION

The law provides for a full time salaried administrator and a licensing board of eleven members, appointed by Governor. The service associations in each of the eight congressional districts each submit the name of an appointee who must be actively engaged in the radio or TV service business at least five years prior to appointment. The three members at large are appointed from names submitted by the IBEW technicians, actively engaged in the broadcast industry. This board meets at least once every four months. All expenses of the operation are taken from fees collected from the licenses, so that the whole operation is self-supporting and requires no tax monies. A yearly report must be furnished to the governor each January on the complete operation.

This Board passes on the qualification of each applicant and hears all complaints, which must be bona fide signed statements.

The typical "Grandfather's Clause" applied to all active servicemen, allowing one year to register with the Board. After this period all applicants must take examinations before qualifying.

RESULTS

From the viewpoint of an operating TV station, we notice the lack of calls complaining about poor service. These were formerly received two or three times daily. Fewer calls are received about poor reception, indicating more efficient servicing.

The general public now has the confidential feeling that they have a reason to expect reliable service work and it has established a greater confidence in the medium as a whole.

The experiences of the board have been multitudinous and varied. They have taken the stand that they are not in a position to punish anyone unless the person is a deliberate multiple offender. In most cases, when the serviceman realized that he was being policed, he was more than willing to make good his error and promised to be a good boy.

A second phase of control has been exercised in the field of misleading advertising. The board prosecuted the licensees on the grounds of unethical conduct by advertising of any character in which untruthful or misleading statements are made, or conduct of any character likely to mislead, deceive, or defraud the public.

Additionally, the board has instituted a public relations program, aimed at raising the overall opinion by the public of the ability and integrity of the technician.

There have been several cases of deliberate offenders whose licenses have been revoked or who fled the state to avoid prosecution. One of these was a national chain operating in the suburbs of large cities and advertising picture tube replacement at ridulously low prices. The evidence against them showed that they replaced the picture tube as promised but always did additional work at exorbitant prices, compensating for the reduced tube price. One man was tried for charging new prices for used (I don't mean rebuilt) picture tubes and parts.

A common offender was the man who offers a very low or no service charge but who slips the charge into his bill as labor, and insists on repairing the set, whether or not the customer wishes.

A fear was expressed, at the outset, that this law might reult in fixing prices or the restraint of trade. So far, there is still enough competition among the servicemen that this is hardly possible.

The secondary purpose of the board is that of educating and upgrading the service technician. Within six months of its inception, the board had set up schools all over the state in co-operation with the Louisiana Department of Education to upgrade the service technician. The response to these schools was overhwelming. Most of the schools are operated as extension classes of existing trade schools.

The manufacturers' representatives responded very generously in donating both modern test equipment as well as late model receivers. In some areas, even closed circuit TV systems were received.

With all these innovations to improve the competence of the radio and TV servicemen, it becomes a more attractive occupation to many men who were looking to the every expanding manufacturing industry for employment. It also meant that set owners no longer had to look to "captive service" for reliable work, but could deal with the independent technician with confidence.

As all of you appreciate, the many improvements in receiver manufacturing, such as printed circuits, transistors, improved vacuum tubes, and the like, have greatly reduced the need for servicing. This calls for more alert servicemen to service, and eliminates many of the less capable. It has sent many of them into the "sales and service" type of shop with the slogan of "Buy your set from the man who will service it properly for you".

The Better Business Bureaus are the ones who appreciate this licensing procedure. It has reduced their complaints to a nil, even easing the problems of misleading advertising.

The licensing law has not lessened the "Do It Yourself" field and the drug store tube checkers are flourishing. The servicemen are countering by putting tube checkers in their shops so they can get the jobs that the amateurs cannot repair.

In conclusion, it must be said that the radio and TV service technician has been upgraded by this law at no increase in cost of competent service work. The public has benefited by a greater confidence in the work performed, so that the industry as a whole is improved. It has long been felt that an industry must consider all of its facets and the radio and TV serviceman has long been a weak spot, which this license law has greatly improved.

STATE RADIO AND TELEVISION TECHNICIANS BOARD

LICENSING LAW

Act No. 428 of 1958

As Amended Through 1960

R. S. 1950, Title 37, Chapter 27

HAROLD J. YURATICH

Administrator

STATE OF LOUISIANA

RADIO AND TELEVISION TECHNICIANS

BOARD

ROOM 221

422 ROYAL STREET

NEW ORLEANS

TABLE OF CONTENTS

of registration to any applicant other than one from city which had a population of 20,000 or more on Ju 30, 1958, without requiring any examination, provid the applicant shall evidence under oath that he is good character and has been a resident of the State Louisiana for at least one year immediately precedi the date of his application, and has been engaged f one year in the business of maintaining and repairi television or radio receivers on July 30, 1960. No oth person shall be issued a certificate of registration wit out first meeting all the requirements of this chapte Nothing herein contained shall be construed as requi ing commercial or industrial establishments to use th services of persons covered by this chapter in the re pair or maintenance of radio or television receivers i their business.

As amended, Acts 1960, No. 324 § 1

Section 2318: Repealed, Acts 1960, No. 324 § 2

The repealed section, enacted in 1958 (Acts 195 No. 428) related to restricting jurisdiction to cities ha ing a population of 20,000 or more.

Section 2319. Penalty: Whoever violates any of th provisions of this act shall be fined not less than $5 nor more than $300, or imprisonment for not more tha 90 days, or both.

Section 2320: That all laws, or parts of laws, co trary to or in conflict herewith, be and the same a hereby repealed.

.in services or parts are necessary or have been or will e used in the repairing of a television or radio re- eiver although such services or parts are not neces- ıry or have not been used in such repairs.

Section 2314. Hearings: Any person, whose certifi- ate of registration is sought to be revoked under the rovisions of this act, shall be given 30 days notice, in vriting, enumerating the charges and specifying a date or a public hearing thereon. The hearing shall be ıeld in the Parish where the person's business is con- lucted. The board may issue subpoenas, compel the ıttendance and testimony of witnesses, and place them ınder oath, the same as a District Court in the Parish vhere the hearing takes place.

Section 2315. Appeals: From any revocation, the erson charged may, within 30 days thereof, appeal o the District Court for the Parish in which the hear- ng was held. A stenographic record of all proceed- ngs before the board shall be made and a transcript ept on file with the board. The secretary shall trans- nit to the District Court a certified copy of the record. The District Court shall try the appeal de novo.

Section 2316. Re-registration of a Revoked Certifi- ate: Any person whose certificate of registration has een revoked for any cause other than failure to pay he annual renewal fee, may, anytime after the revoca- ion, apply to the board to be re-registered. Upon atisfactory proof that the cause of revocation no onger exists, the board shall issue to such person a ertificate of registration upon payment of the fees rovided herein.

Section 2317: Certificates without examination; aths; commercial or industrial establishments.

* *At any time within one year after July 30, 1960 up- n the due application therefor, and the payment of he registration fee, the board shall issue a certificate*

*Part of Section 2317 indicated in italics was auto- natically repealed by time stipulation on July 30, 1961.

STATE RADIO AND TELEVISION TECHNICIANS BOARD

Act No. 428 of 1958
Amended Through 1960

To regulate and define the practice of radio and television receivers maintenance and repair service in cities having a population of 20,000 or more to create a board to be known as the State Radio and Television Technicians Board for the registering and licensing of persons to engage in said service; to provide examinations for applicants for licenses for the maintenance and repair of radio and television receivers as used in the home, and to establish standards for said examinations; to prescribe qualifications therefor; to fix examination and qualification fees; to provide penalties for the violation of this act; and to repeal all laws or parts of laws in conflict herewith.

Section 2301. General Provisions: Be it enacted by the legislature of the State of Louisiana that, in order to protect the public welfare, aid the Revenue Department in collecting Sales Taxes on labor and on retail prices of material used in the service and maintenance of television and radio equipment; to protect privately owned property and to provide an adequate supply of skilled technicians throughout the state by the establishment of an apprenticeship program in accordance with the state apprentice training program, any person rendering or offering to render professional service for the maintenance and repair of any type of television and radio receivers as used in the home shall hereafter be required to be registered and licensed as hereinafter provided, and it shall be unlawful for any person to practice or offer to practice in the State of Louisiana radio and television maintenance and repair service unless duly registered and licensed in accordance with the provisions of this act; that there is hereby created a board to be known as the State Radio and Television Technicians Board.

Section 2302. Definitions: The following words or phrases, when used in this act, shall have the following meaning:

(1) "Board" shall mean the State Radio and Television Technicians Board.

(2) "Radio and television receivers maintenance and repair service" means responsible service which may include consulting, maintenance, general servicing and repair of any and all makes of radio and television receivers as used in the home.

(3) "Technician." The term "Technician" means any person who by means of his special knowledge, acquired through formal education or practical experience, or both, is qualified to maintain and repair television and radio receivers, and is legally registered and licensed as such, in accordance with the provisions of this act.

Section 2303. Qualifications and Terms of Boards: The State Board of Registering and Licensing of Technicians for the maintenance and repair of television and radio receivers as used in the home is hereby created. The board and the boards thereafter shall consist of eleven members appointed by the Governor. Each member of the board shall have been a resident of the state for five years immediately prior to his appointment. Eight members shall have actually been engaged in the business of maintenance and repair of television and radio receivers, as used in the home, for at least five years prior to their appointment. The board and each subsequent board shall be appointed by the Governor in the following manner. Duly qualified organizations of radio and television technicians chartered by the state shall submit the names of not less than two nominees from each of the eight Congressional districts. From this list there shall be appointed one member form each Congressional district. The other three members shall be appointed from at

Certificates of registration expire on December 31 of each year, and may be renewed for one year upc the payment of the renewal fee provided for herein.

Section 2311. Failure to Renew Certificates; Rei statements: The board may revoke a certificate c registration upon the failure of the holder to pay th annual renewal fee, upon giving the holder 30 day notice, in writing, by registered mail sent to his las known address, of the proposed revocation. Th holder of such revoked certificate may be reinstate upon the payment of the accrued fees and a penalt imposed by the board, not exceeding twice th amount of delinquent fees.

Section 2312. Fees: The board shall charge the fol lowing fees:

(1)	Television and Radio Examination and Certificate Fee	$25.0
(2)	Re-examination Fee, Radio and TV	10.0
(3)	Renewal Fee, Radio and TV	15.0
(4)	Radio only, Examination and Certificate Fee	10.0
(5)	Re-examination Fee, Radio only	5.0
(6)	Renewal Fee, Radio only	5.0
(7)	Certificate Fee for Apprentice	10.0
(8)	Temporary Certificate	5.0
(9)	Renewal Fee for Apprentice	5.0

Section 2313. Revocation of Certificates: The boar may revoke any certificate of registration upon proo (1) that the certificate was obtained through error c the board or fraud on the part of the applicant, c (2) that the holder is grossly incompetent, or is guilt of unethical conduct. Unethical conduct means (1 any conduct of a character likely to mislead, deceiv or defraud the public; (2) advertising of any characte in which untruthful or misleading statements ar made; (3) the performance of any service in pursuanc of any such advertising; (4) the representation that ce ommittee shall determine the questions and answers ı be used and shall change the questions and answers om time to time so they shall be parallel to the prog- ess being made in the radio and television field.

The applicant for a license as a technician shall have een licensed at least two years as an apprentice or hall have had at least two years experience in the re- ıair, service, or maintenance of radio and television quipment and shall furnish affidavits from two other ersons engaged in the same work to the effect that he applicant possesses the above qualifications.

The examination for technician shall consist of 50 uestions in multiple answer form as used in the ap- rentice technician examination, but shall be advanced nd shall be a different set so as to require a greater nowledge of the subject. Each correct answer to uestions shall be worth two percentage points and ı passing grade of 74 shall be required. The questions nd answers used in the above examination shall be rawn up by the same committee appointed by the State Radio and Television Technicians Board.

After passing the examination, and upon the pay- nent of the prescribed fee, a license good for one year hall be issued the applicant, which may be renewed s hereinafter provided.

A licensed technician may service or repair any radio nd/or television equipment as used in the home as ong as his license is current and has not been revoked or cause.

Section 2310. Issuance of Certificate: If the appli- ant successfully passes the examination, the secretary f the board shall register this fact and issue to him a ertificate of registration. The board may issue a emporary certificate for any period between the date f the application for examination and the necessary cheduled examination upon payment of the fee for emporary certificate provided for herein. The certifi- ate issued by the board shall at all times be con- picuously displayed at the holder's place of business.

least six nominees recommended by the International Brotherhood of Electrical Workers who are engaged in the television and broadcasting industry. Each member shall be appointed for a term of two years. All vacancies for any unexpired term shall be filled by appointment by the Governor from among nominees recommended by the same groups that submitted the original nominees. The removal from the state or the revocation of the certificate of registration of a member of the board shall immediately terminate his membership on the board. The members of the board, before entering upon their duties, shall take and file their official oath of office. The board shall meet at least once every four months in Baton Rouge, Louisiana, and may hold special meetings at the call of the secretary at any time or place within the state. A majority of the members of the board shall constitute a quorum. The board shall annually elect one of its members as chairman and one as secretary. Each member of the board shall be paid a per diem of $25 for the performance of his duties while attending meetings of the Board; he shall also be paid all necessary travel expenses. He shall also be reimbursed all actual and necessary subsistance expenses, not to exceed $15 per day.

Section 2304. Board Funds: The secretary of the board shall receive, disburse and account for all moneys paid to or received by the board. He shall institute a system of books and financial records satisfactory to the State Auditor, who shall audit them annually. He shall open an account in a bank designated by the board as its official depository, and he and one other officer of the board shall both sign all checks disbursing funds of the board. The secretary shall keep a full and complete record of all proceedings which shall be open to inspection by any members of the board or authorized representative, at all reasonable times. He shall be the custodian of and shall collect all fees. He shall give a bond in a reasonable amount, to be determined by the board.

Section 2305: The board shall appoint an administrator, who shall be paid an annual salary to be fixed by the board, to administer and enforce the provisions of this act; the board may adopt and enforce all necessary rules, regulations and by-laws not in conflict with law, or with the provisions of this act, in providing for the conducting of examinations for the licensing of applicants in accordance with the standards set forth herein.

Section 2306. Reports: The board shall, on the 15th day of January of each year, make a written report of its proceedings, verified by the secretary, and submit it to the Governor. The report shall include a detailed statement of receipts and disbursements during the preceding year, and a statement of the board's actions and proceedings and a list of all registered technicians in the state.

Section 2307. Registration Certificate: No person shall engage in the business of maintenance and repair of television and radio receivers as used in the home unless he first obtain a certificate of registration as provided for herein.

Section 2308. Qualifications and Requirements of Applicants: Applicants for certificates as technicians to engage in the business of maintenance and repair of television and radio receivers shall possess such general education, training and experience as needed to meet standards as provided for herein.

Section 2309. Examinations: Applicants for certificates under the provisions of this act shall be examined at a time and place fixed by the board; said examination shall be held not less than twice a year. Applications for examination shall be filed with the board at least ten (10) days before the date set for the examination and shall be accompanied by the examination fee prescribed herein.

The examination shall be confined to the knowledge, practical experience and skill necessary and essential to the proper maintenance and repairing of television

and radio receivers as used in the home, and a pract
cal demonstration of the applicant's skill in conne
tion therewith. Any individual engaged in the repai
service or maintenance of any radio and television re
ceivers as used in the home must be licensed as here
inafter provided.

There shall be two classes of licenses to be know
as: Apprentice License, and Technician License.

An Apprentice License shall be issued to any in
dividual after the applicant has taken and passed
written examination with a grade as provided herein
upon the payment of the examination and certificate
fee. No holder of an Apprentice License may serv
ice, repair any radio or television receiver as used i
the home unless a licensed technician is present whil
such work is being done. Before an Apprentice Li
cense shall be issued to an individual he must b
registered with the Federal and State Department
of Labor.

The written examination for the Apprentice Licens
shall consist of 50 practical questions of the multipl
answer form such as used by the United States Civi
Service and Municipal Civil Service examining board
at the time of the passage of this act. Each correc
answer shall be worth two percentage points, and t
receive a passing grade, a total of sixty-two (62) per
centage points shall be required.

In scoring the examinations, honorably discharge
veterans shall be given a perfenence of five percentag
points.

An examining committee shall be appointed by th
State Radio and Television Technicians Board for th
purpose of conducting examinations. This committe
shall consist of five members, three of whom shall b
instructors from accredited schools teaching electron
ics, radio, and television maintenance and repairs, an
two members who are expert television technicia
now employed and working at the repair, diagnose
and servicing of television and radio equipment
leading television and radio service companies. Th

You Can Help...

Yes, you, the consumer, CAN help your Technician provide a better service for YOU by taking an active interest in each request for service.

- Examine carefully all advertisements which attract you to the services of a Technician.
- Specify fully your service needs in a manner to aid your Technician.
- Call special or unusual circumstances to his attention BEFORE repairs begin.
- Inspect his billing of your receiver repairs upon completion of work.
- Read and understand his guarantee or warranty.
- Do not allow "tinkering" by unqualified persons before requesting the services of a Technician.
- Read carefully the balance of this folder and be prepared when next you require service.

First, a word of caution about...

ADVERTISING

> **ACE TV SERVICE**
>
> PROMISES
>
> YOU
>
> **FAST SERVICE . . .**
>
> **DEPENDABLE SERVICE . . .**
>
> SERVICE YOU WILL LIKE
>
> **SIMPLY CALL . . . 234-5678**
>
> 4040 MAIN STREET

The consumer's first contact with a service transaction is generally made through an advertising media. Advertising is a valuable means of knowing about the services of the Technicians, but it may mislead the consumer into expecting more in value than is actually intended by the advertiser.

All advertising, whether circular, newspaper or radio and television, should clearly indicate the manner in which the service is to be performed and any limitations which the consumer may expect to be attached to the service. Components offered as part of the service should be fully identified as to type and condition in the same manner as they will be invoiced to the consumer.

Now, let's examine the responsibility of both THE TECHNICIAN and THE CONSUMER by means of sample repair bills.

(Please Turn Page)

ABC TV SERVICE 97758

1234 NORTH STREET
YOURTOWN, LA.
PHONE: 279-6846

NAME MARY Johnson	APT. 3	DATE 1/3/61	
ADDRESS BERWICK APTS.		DELIVERY PROMISED 1/10/61	
CITY YOURTOWN	PHONE 275-7351	REPAIRED IN ☐ HOME ☒ SHOP	
MAKE FULVUE	MODEL 320	ESTIMATE ✓	DELIVERY ☒ OURS ☐ PICK UP

SERVICE REQUEST NO PIX-, PIX WAS SNOWY, NOT CLEAR; SOUND LOW

DETAIL OF CHARGES

QUAN.	PARTS, TUBES, MATERIALS	PRICE	
1	12 A X 4 DAMPER TUBE	0	00
2	6 AU6 - 2ND IF + 1ST	0	00
	AUDIO TUBES	0	00
1	470 Ω ½ WATT RESISTOR IN TUNER	,	00
	CLEAN + ADJUST TUNER CONTACTS	00	00
1	21A P4A PICTURE TUBE		
	(REBUILT USED GLASS ONLY)	00	00
1	HORIZONTAL FLYBACK		
	TRANSFORMER - NEW	00	00

GUARANTEE: All work performed by qualified licensed technicians, all materials used in repair of this unit are of first quality and guaranteed for a period of ninety days after date of repair.

TOTAL PARTS, TUBES MATERIAL	00	00
TECHNICAL SERVICE TIME	00	00
PICK UP, DELIVERY OR SERVICE CALL	0	00
TAX	0	00
TOTAL (C. O. D.)	00	00

Set owner's signature indicates satisfactory performance of set at time of delivery or completion of repairs in home.

Owner: ________

Technician: ________

REMARKS:

Guarantee includes 1 year warranty on picture Tube - 90 Days on Installation, Face Plate Glass - Scratched, Not Replaced as per Agreement.

INVOICING: Detoiled invoices or receipts should be is for work performed.

EXAMPLES

Name, location and phone listing should appea the face of all billing.

Accurate Filing Information and history of rece should be stated in full.

Service request should reflect the customer's sta ment of work to be performed and the condition receiver at first inspection.

Number and type of parts and tubes should be cle indicated.

Major component replacement or repair should cle state the nature of repair

OR

condition of replacement unit.

GUARANTEES: Guorantees ond worronties should sp fically define the terms and speciol conditions gran the customer. The common proctice is to porallel warranty of the monufacturers on parts and guarai the installation for an equal period.

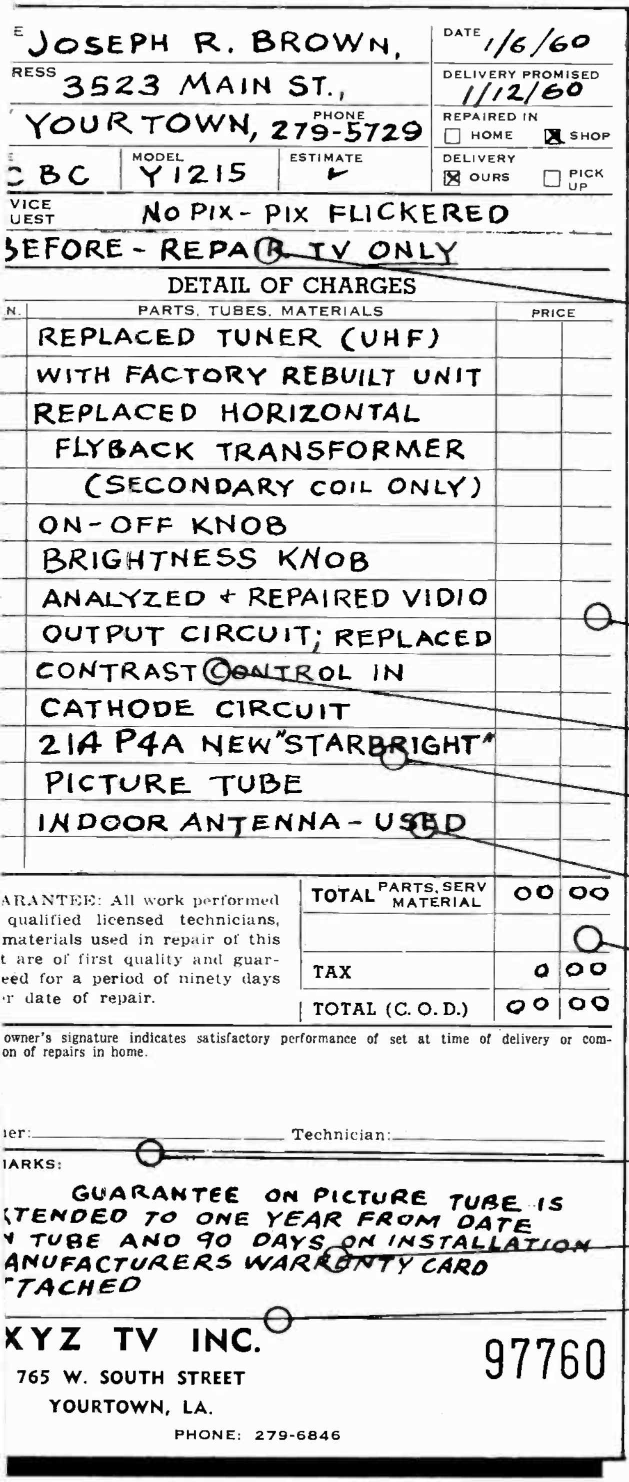
EXAMPLES

The repairs to your receiver are guaranteed for (ninety days from date of invoice, conditioned on t pering or misuse, which would render this guara void.

Note: The guarantee stated on this invoice is ditioned on acceptance of the estimate and prov all charges are paid in full.

Note: The guarantee stated on this invoice is he limited to the parts and service indicated as actu performed by your request and does not include tions of the estimate not accepted.

THE CONSUMER


E JOSEPH R. BROWN, DATE 1/6/60
RESS 3523 MAIN ST., DELIVERY PROMISED 1/12/60
YOURTOWN, PHONE 279-5729 REPAIRED IN ☐ HOME ☒ SHOP
BC MODEL Y1215 ESTIMATE DELIVERY ☒ OURS ☐ PICK UP
VICE UEST NO PIX - PIX FLICKERED
BEFORE - REPAIR TV ONLY

DETAIL OF CHARGES

N.	PARTS, TUBES, MATERIALS	PRICE	
	REPLACED TUNER (UHF)		
	WITH FACTORY REBUILT UNIT		
	REPLACED HORIZONTAL		
	FLYBACK TRANSFORMER		
	(SECONDARY COIL ONLY)		
	ON-OFF KNOB		
	BRIGHTNESS KNOB		
	ANALYZED + REPAIRED VIDIO		
	OUTPUT CIRCUIT; REPLACED		
	CONTRAST CONTROL IN		
	CATHODE CIRCUIT		
	21A P4A NEW "STARBRIGHT"		
	PICTURE TUBE		
	INDOOR ANTENNA - USED		

ARANTEE: All work performed qualified licensed technicians, materials used in repair of this t are of first quality and guaranteed for a period of ninety days r date of repair.

TOTAL PARTS, SERV MATERIAL	00	00
TAX	0	00
TOTAL (C. O. D.)	00	00

owner's signature indicates satisfactory performance of set at time of delivery or completion of repairs in home.

ner: ______ Technician: ______

IARKS:

GUARANTEE ON PICTURE TUBE IS EXTENDED TO ONE YEAR FROM DATE N TUBE AND 90 DAYS ON INSTALLATION ANUFACTURERS WARRANTY CARD TACHED

XYZ TV INC.
765 W. SOUTH STREET
YOURTOWN, LA.
PHONE: 279-6846

97760

SERVICE REQUESTS: **One of the common causes of misunderstandings on service is the failure of the Consumer to clearly state to the technician the type of services which are desired and those which should not be performed or considered optional. The extent of service that is desired should be clearly stated when placing a request for the services of a Technician.**

EXAMPLES

"Please repair the television section of my combination only. I am not interested in the record player at the moment."

"I do not use the remote control feature. Please repair only the television receiver itself."

"I know my outside antenna is in need of repair, but I would like to have my set repaired before agreeing on the antenna."

ESTIMATES AND BILLING: **Misunderstanding after service is completed can be prevented by following a few simple rules.**

Request an estimate if major repairs are indicated. Demand a receipt upon completion of repairs.

Check the receipt to insure that statements of work performed agree with the estimate and clearly show the nature of trouble and measures taken to correct it.

When a type or grade of component is requested, be sure that such is indicated on the receipt.

If price is to be considered, ask what can be expected of a cheaper component before authorizing its installation.

Only parts and service performed can be expected to be guaranteed as charged for on the receipt.

GUARANTEES: **Check the guarantee to fully understand its terms and conditions.**

Before signing acceptance inspect receipt to determine which items are covered in the guarantee.

Ask for any warranty issued by the manufacturer; as in picture tube warranty cards.

Check the shop name, address and phone number to know who is issuing the guarantee and where to call if further service should be needed.

The Television and Radio Technician in Louisiana has placed the responsibility for assuring your satisfaction under the Laws of this State. You are, therefore, supplied an additional method of recourse in any complaint you may feel justified to lodge against improper workmanship or misrepresented services.

Direct all inquiries to:—

Louisiana State
Radio and Television
Technicians Board
3013 Tulane Avenue
New Orleans, La.

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"A LICENSE GUARANTEES THE SERVICE"

Mr. and Mrs. Television Viewer....

Perhaps you had never given thought to the complexities of returning your T.V. or Radio receiver to proper working order until you were faced with an annoying "break down". Only then were you presented with the further problem of selecting a repairman on the basis of his ability and integrity as indicated in an ad you had heard or seen. Or, maybe you trusted the selection to your judgment or personality and character after meeting him through a friend.

These are important traits to judge by; more important is the outcome of the service after your selection had been made. Did you understand and were you satisfied with the work performed?

In Louisiana, the consumer of Television and Radio Service is fortunate to have available the services of qualified, Licensed Technicians. This relieves some of the burden of your original selection of a Technician.

Now that your choice has been made . . .

EXPERIENCES IN MOVING A TELEVISION TRANSMITTER WITHOUT LOSS OF AIRTIME

Higher towers and new transmitter locations seem to typify the phase of TV development thru which we are now passing. Many stations have moved in the recent past. Others will be moving in order to solidify their positions in terms of the trade area to be served.

This discussion will deal with two aspects of moving:

1. The plans and execution of the actual mechanics of moving a transmitter without loss of air time.
2. The job that falls upon the engineering department before and after the move in realted areas such as public relations.

I won't attempt to deal here with the problems of finding a suitable site, obtaining FAA approval or similar matters, since these are individual problems. Rather, I'll try to explain our move in terms of the problems which may be yours should your management decide to go to a more favorable location.

Our station moved from a transmitter location three miles west of the City of Rochester, Minnesota to a new location 32 airline miles south of that city.

As it worked out, these were the ground rules for our move: The new facility would be equipped with a completely new tower and antenna system, transmission line and Filterplexer. The existing transmitter, an RCA TT-25BH would be moved overnight to the new location with the least possible loss of air time, and come on the air from the new location with maximum power, 316 KW.

Now it may seem that this resembles the problem of building a new school house out of the bricks of the old school house -- but in reality it's not that serious.

Our transmitter employs the TT-10--ten kilowatt unit as an exciter for the 25 KW amplifiers, and it was agreed that we could move the amplifiers ahead of time and utilize only the TT-10 for a few days prior to the final move. This would result in a temporary ERP of 100 KW from the old location.

As to the actual mechanics of the move, we would begin at the time the new building was nearing completion: A wiring sheet was worked out for all wiring external to the transmitter -- the plan being that when the transmitter was set in place, all external wires and coax would be in place and tagged, ready to be routed to the proper terminals. Also, the antenna system including the filterplexer was swept out and carefully inspected. It was not possible to test the system ahead of time under full-power conditions, however the line had been hi-potted and an overall resistance check made. All appeared normal.

Two-way radio was installed between the studio and the new location, then the 7000 mc. microwave link was checked out three weeks prior to the target date. After the original antenna alignment, signal-noise was checked at several different times and the received signal level was monitored continuously.

As soon as the moving schedule was decided upon, a letter request was sent to the FFC asking special temporary authorization under the construction permit for the following steps:

1. On or about December 6th, the existing transmitter will be reduced in power to 100KW ERP. The 25 KW amplifiers will be moved to the new site.
2. On or about December 9th, the complete transmitter will be moved over-night to the new location and will go on the air as soon as possible the following day with full power of 316 KW and normal program service.
3. Following the move, proof of performance measurements will be made and license application filed.

FCC approval of this suggested proceedure was forthcoming, and as the steps were subsequently accomplished. a telegram was sent to the Commission referenced back to step 1 or 2 of this letter.

Now we came to the first phase of the move, which involved the 25 KW amplifiers. It was intended that this step should serve as a dress rehearsal for all hands, including the six employees of the transfer company. The only difference was that this could be accomplished in the daytime and without the pressure of a deadline. Accordingly, the four cabinets and two base units were disconnected the preceeding night, and the 10 KW transmitter was transferred to feed the antenna. Next day the amplifiers were broken down into individual units and loaded into the vans. Each unit was enclosed in a furniture pad and cushioned by setting it on a triple thickness of the pads.

Both aural and visual amplifiers were thus moved to the new site, set in place, installed and checked out. A careful record was kept as to time involved in each operation and this enabled us to more carefully estimate the timing for the final move.

Final arrangements were now made for moving the TT-10 section of the transmitter as follows: One engineer was assigned to each of the six remaining cabinets. Each man was to be responsible for his cabinet. He was to go over a check list of all items that were to be disconnected or dismounted, including coax feeds and air boots between cabinets.

It was planned that when the transmitter was finally shut down, a brief period would be allowed for tubes to cool. During this time each man would "J-stick" all high voltage points in the cabinet. Tubes could then be removed, and each man had a box with packing material in which to carry the tubes. He hand-carried this box in his car to the new site, and in due time re-inserted them in the same sockets. In fact, each man was responsible for re-connecting in reverse everything he had previously disconnected. An individual check-off list assured follow-thru.

Two moving vans were used. One for the aural, the other for the visual transmitter. It was planned to load the visual and get it to the new site first, since it would probably take longer to retune and sweep it out. Additional personel on duty at the new site included the electrician who had wired the building, also an engineer from the RCA Service Company for expert trouble-shooting.

This, then has been a brief summary of the pre-move planning. Now--

How did it all work out?

"M-Day" was a Friday night. We went off the air with regular programming at eleven pm. Everyone jumped to his appointed task, and by 12:30 the first truck departed. The second van followed at 1:30 am. By four am everything was in place at the new location. At 6:30 am, the aural transmitter was checked out on the air, and at 7:30 the visual was ready to feed the antenna. Regular Saturday programming started at nine am. The only unit not operating properly was the aural modulation monitor. No significant trouble was encountered, and it seemed that good luck had been with us all the way.

So much for the actual move. I mentioned previously that the engineering department should be prepared to participate in a program of public information both before and following the move. Of course, this is the province of the promotion department, but we assisted in the following ways: Going back to the time the construction permit was issued, it was decided to enlist the aid of the area TV dealers and servicemen. If they can be fully informed they can dispell rumors and help to give the general public the correct information. We went to the parts distributors who cover the area and asked that they help us to assemble a mailing list of all TV servicemen in the area. This list was then used periodically for direct mail contacts. It is important to include operators of community antenna systems on this list also.

Next we planned a party for all the area servicemen and invited them to come in and help celebarte our eighth anniversary. The event was held on a Saturday with an afternoon and evening program, and included a dinner. The program was oriented toward color -- this because our station has promoted network color since its inception, and the upcoming move would make a good color picture available over a much larger area. During the evening we announced the upcoming transmitter move, discussed the proposed coverage area, and made available a supply of coverage maps which had been reproduced from the one we had filed with the FCC. This event was quite successful, was attended by about 160 servicemen who went away with a first-hand knowledge of what to expect from our move.

The next effort was a little less direct, but it kept us in touch with the servicemen. We made a survey as to how many men would like to attend a color servicing school if we would sponsor one, and conduct classes one night a week. About 70 servicemen responded to this, and the result was an eight week course which was conducted by men from the RCA Service Company. The average attendance at the sessions was 56, and several drove as far as 100 miles. This also gave us a chance to give a weekly progress report on the upcoming move.

Our engineering department participated briefly in several newcasts before and after the move. We tried to explain antenna orientation and signal strength. We explained to the people who had been using rabbit ears that a simple antenna properly oriented might now be required. This usually resulted in calls from irate viewers complaining that what we called a simple antenna was being priced to them at 70 to 80 dollars or more. Then servicemen would call and take issue with us for telling their customers to put up a simple antenna when they obviously needed an all-channel antenna and rotor.

Then of course there were a few good sponsors who were unhappy with home reception. These had to be taken care of on an individual basis.

It all serves to point up the fact that when a transmitter is moved 32 miles from the principal city, it causes a great deal of consternation to viewers in that city. They are not easily appeased. On the plus side are all the original objectives of the move, and in our case it was well worth the time and expense involved.

Robert W. Cross, Ch. Engr.
Southern Minnesota Broadcasting Company
KROC KROC-TV
April 4, 1962

THE TRANSITION TO TRANSISTORS IN TELEVISION

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The advantages of solid state devices and techniques in design and construction of TV terminal equipment are discussed. The design of practical, electrical and physical arrangements for replacing existing tube amplifiers is stressed. The problems in the design of an amplifier for video and pulse use are discussed. One year's experience with a large number of transistorized pulse/video distribution amplifiers will be reported upon, including transistor life, stability of operating characteristics et cetera.

Figures are given on the relative cost of air conditioning tube and transistor amplifiers. Various types of transistorized video amplifiers developed and available are enumerated.

It is remarkable that the television industry, which is considered a relatively new one, has been slow in adapting new techniques to its transmission problems. By and large, studio equipment uses the same basic design philosophy today as it did shortly after World War II. The transistor was invented in 1946. Although there were early difficulties which have now been overcome, there has been a large gap between the perfection of the transistor and the common use of it in television stations. When television began, of course, we had nothing but vacuum tube amplifiers. These amplifiers are inherently high impedance devices. Television with its wide frequency band and coaxial cables is essentially a low impedance technical art. Transistors being low impedance devices match the television art almost perfectly which accounts for the fact that one can deliver 1 volt peak to peak into a 75 ohm line from a tiny transistor which dissipates only a few milliwatts whereas a large tube dissipating watts is required to do the same thing. The transistor does it more efficiently and does it over a wider band with simpler circuitry. Before the advent of the diffused base mesa type transistor there was a question as to whether transistors would be able to handle easily and efficiently the frequency band required in television. This type transistor not only handles the band but much more and without the use of peaking coils. The diffused base mesa transistor was first described by C. A. Lee of Bell Telephone Laboratories in the January, 1956, B.S.T.J. It is being manufactured by Texas Instruments and Motorola at the present time for sale to the industry generally. There are some other types such as the MADT epitaxial and planar which are offshoots of this basic type, we are told. The 2N1143 transistor which is of the diffused base mesa type has an alpha cutoff of about 650 megacycles. This high cutoff frequency makes it possible to design video amplifiers having large amounts of degenerative feedback in the overall loop which is active far beyond the band required for picture transmission which in turn makes the amplifier quite stable. Through this technique it is possible to stabilize transistorized amplifiers against temperature changes, gain changes and differential phase.

Now that we at WSM-TV have had operating experience with transistorized distribution and camera pre-amplifiers we can say with assurance that transistors have among others the following advantages:

(1) A long life which apparently is much greater than tubes. At the present time we have approximately 350 transistors in operation. To date we have lost nine transistors although they operate 24 hours per day. Eight of these have been lost only because of the presence of large discharge currents from tube amplifiers which were fed into them inadvertently; one unit expired for unknown reasons. Now with proper protection circuits there is no further difficulty from this source. To date we have logged 2,200,000 transistor hours. Not counting the eight failures due to tube amplifier transients we have averaged 6,000 hours per transistor and they are all still operating. We understand transistors are now being engineered into future undersea cables for 20 years service or more.

(2) Transistors have highly stable operating characteristics. Once they are designed into equipment there is no noticeable deterioration of picture quality with time.

(3) The amount of heat dissipated in transistor amplifiers is microscopic in comparison with equivalent tube amplifiers. Reliable information obtained from air conditioning engineers shows that the cost of air conditioning is about $23 per year for each kilowatt of heat extracted when depreciation, maintenance and power costs of air conditioning equipment are considered.

(4) Transistors are non-microphonic and since they do not have filaments there is less liklihood of developing glitches in the system than with the tube amplifiers.

(5) Transistor amplifiers reach their proper operating condition within a few seconds after being turned on and remain in that condition over indefinite periods of time.

(6) So far we have found it possible to design equipment using only one or two types of transistor which greatly reduces the stockage problem.

In February, 1961, we undertook the design of a transistorized video/pulse distribution amplifier thinking that this would be the best place to start since a large number of distribution amplifier, both pulse and video, are used in any given station. The result was the TDA2 amplifier which is now manufactured by the International Nuclear Corporation of Nashville, Tennessee. In Slide 1, we have a picture of this amplifier alongside a tube amplifier with a power supply. The transistor amplifier has its own power supply included and draws a total of 4 watts from the power line. Its characteristics are now well known in the industry since hundreds have been purchased by a wide variety of organizations, including networks and telephone companies. This amplifier has a maximum gain of 4.5, it has a band width of 10 megacycles to the quarter db point and it will deliver up to 1.5 volts peak to peak at four outputs which are virtually independent of each other. In addition, it will deliver 4.1 volts of pulses when it is used in this service. A check over the past year has shown no deterioration whatsoever in the pulse output of a large number of these amplifiers even though they are banging away 24 hours per day.

This single improvement has in our opinion justified the changeover to transistorized amplifiers for before this we were constantly replacing tubes in pulse distribution amplifiers in order to maintain the required 4 volts in our system. The amplifier utilizes 7 Texas Instruments 2N1143 transistors The first two stages are common emitter types and use feedback in each stage to stabilize the operating characteristics. The last two stages are emitter followers. This form is used in order to achieve low output impedance to drive the four output stages and in turn the four coaxial cables. Each output stage impedance is only 1 ohm which is built out to 75 ohms by resistors. When used in pulse service a switch in the amplifier connects a zener diode across the output of one of the stages which clips the pulses top and bottom squaring them up and providing a high degree of regulation at the output.

The design philosophy used in this amplifier was that we would produce a piece of equipment which could replace tube amplifiers with a minimum of change in our rack system. We saw no need for extreme in miniaturization of the equipment and thought that the amplifiers should be designed and mounted in standard relay rack mountings. The height of the equipment is only 1 3/4 inches. We also thought it worthwhile to include a power supply in the amplifier for the amount of power consumed is so small as to make redundancy in power supplies practical and worthwhile.

The maintenance of pre-amplifiers in camera equipment has always been a station problem. These amplifiers have a fairly high gain. They operate at low levels and are subject to microphonic troubles.

In Slide 2, we have a photograph of a transistorized amplifier and power supply which replace the tube pre-amplifier. The tube pre-amplifier has a total dissipation in the camera of 40 watts whereas the transistor amplifier uses a maximum voltage of 25 and has a total dissipation of about 1 watt. Its band width is the equivalent of the tube amplifier. It is non-microphonic and so far as we can tell will have an indefinite life. The peaking coil seen in this slide serves to correct the orthicon drop off at high frequencies and not the transistors.

Some months ago we undertook the design of a 26 db gain amplifier for one of the large companies to be used at branching outputs of cameras. The design is now completed and this amplifier is being manufactured by International Nuclear Corporation. It utilizes eight 2N1143 transistors, has three outputs and its own internal power supply. It has gains which are adjustable at steps of 16, 22 and 26 db. The gain temperature co-efficient is practically negligible, the gain increasing approximately .6 decibel between 20 and 60 degrees Centigrade.

Recently we have designed a 9 db amplifier known as the TDA9 which uses four 2N1143 transistors. This amplifier is of module construction and is intended to be used in large systems where 10 to 20 amplifiers might be cascaded. It is highly stabilized against gain changes and uses approximately 20 db degenerative feedback around the loop. Gain change is less than 1/10 decibel up to 60 degrees Centigrade. A large number of these amplifiers can run from a common power supply which will be included in the module rack. The power supply was designed so that any number of similar power supplies can be paralleled. Each will have a series silicon diode so that if one supply goes out the others will assume the load automatically and carry on.

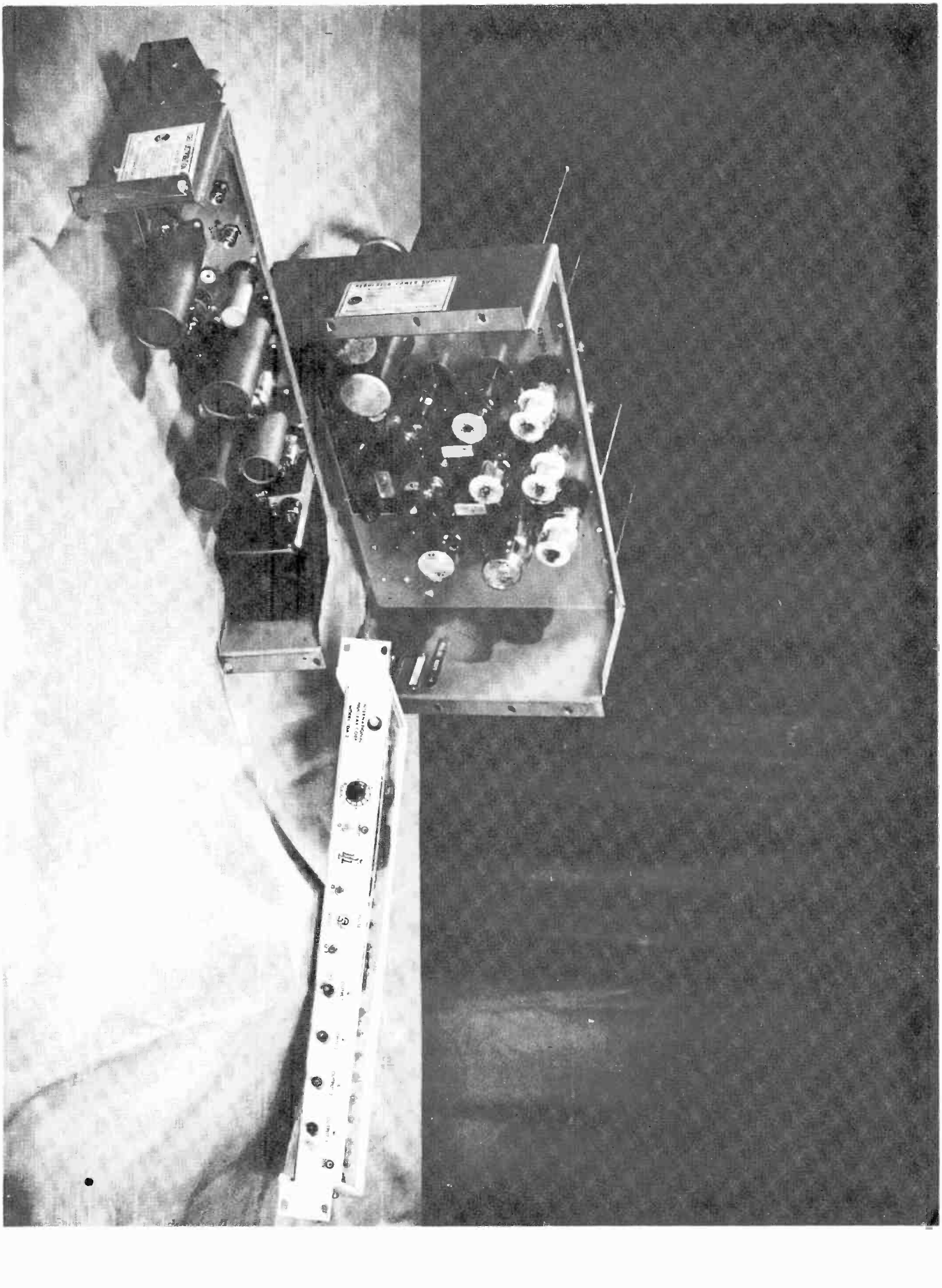
We also have under test an experimental amplifier known as the TUBA1. It has a differential input and a balanced output for feeding 124 ohm telephone cables as well as a coax output for monitoring purposes. The differential input is such that a hum voltage present on the outside of the coaxial cable feeding the amplifier is suppressed 40 db which in most cases will render the hum negligible. This amplifier should be quite useful where glitches are troublesome or when there is a potential difference between a remote truck and a phone company circuit.

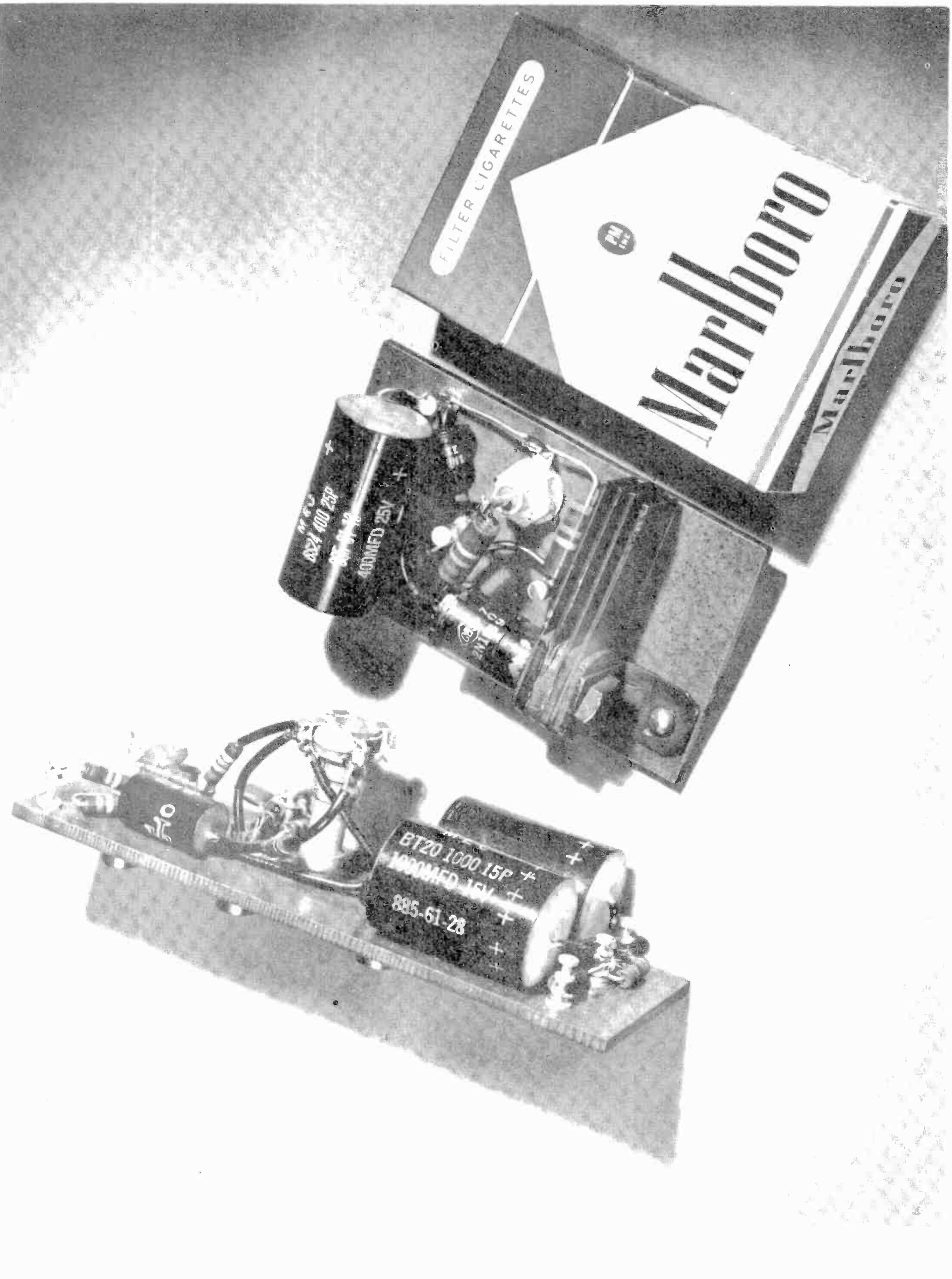
In formulating a design philosophy for all of these amplifiers it was quite apparent that simplicity and reliability should be the keynote. We attempt to use one type transistor or at most two; we use circuits that are simple. We use no trick circuits such as complementary type transistors or dc balancing circuits. We have been able so far to avoid the use of peaking coils or other items which are subject to misadjustment in the field. We are careful to see that the transistors run as cool as possible in order that they will not be at any time subject to thermal runaway even though the temperature in the racks may go to 60 degrees Centigrade (140 degrees Fahrenheit). We have chosen transistors which are used in some of the large government missile contracts and which are likely to be available for a very long period of time.

Conclusion

The use of transistors in the television station has without doubt a very bright future. General use of well designed transistorized equipment will greatly reduce maintenance cost in any given station. It will do much to solve the heat problem which has always been with us and it will improve picture quality over long periods of time. These accomplishments will be the delight of management as well as a comfort to the chief engineer.

In closing, I would like to recognize the contributions of Mr. Aaron Shelton, Chief Engineer of WSM-TV, and his people to this effort.

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