Book # 1

# SPECIALIZED TELEVISION ENGINEERING

## TELEVISION TECHNICAL ASSIGNMENT

## FUNDAMENTAL IDEAS



701D

# A CHAT WITH THE CHIEF INSTRUCTOR

## FOREWORD

*In starting your home-study course, you are taking the step which, carried through to a successful completion, has enabled many of the leaders in American industry to obtain their professional training.*

## HOW TO MAKE A SUCCESS OF YOUR CREI COURSE

*John R. Kelley*

If you could visit in my office at CREI we would chat for a few minutes to get acquainted. I would introduce you to members of the staff and, if you had the time, show you through the school. Then, after we began to know each other, I would tell you some of the things that my experience in supervising the work of thousands of CREI students has taught me about how to successfully complete a course in radio engineering.

Possibly you have never before studied a course by home study. In that case you undoubtedly are wondering, "How do I get started?" "Is it as difficult as some of my friends have told me?" "Can I really learn anything by this method?" "After I have put in all the work will anyone recognize it?", and many more questions.

Some of the answers are: Yes, you CAN learn by this method. Most adults acquire their advanced education by reading and studying independently. What the home-study course does is substitute an *organized* program of reading and studying plus the addition of frequent examinations and the consultation services of a trained, competent instructor.

Home study is *individual* study. You can take just as long as you find necessary with each section of the course instead of being pulled through by a lecturer at a fixed rate. You can arrange your own study periods to suit your own convenience. You receive individual answers to *your* questions from your instructor. Many people think what *they* haven't tried *must* be difficult. Hundreds of thousands of adults in every kind of profession are *successfully advancing themselves* by this method.

Recognition? Some of the most successful leaders in industry have publicly acknowledged their debt to home-study education. Capt. Eddie Rickenbacker, President of Eastern Air Lines, and the late Walter P. Chrysler are now famous examples of achievement through home-study training. Thousands of industrial organizations sponsor and endorse home-study training for their employees. Among the outstanding companies using CREI home-study courses in their official training programs are All American Radio and Cable Company, A.C. Nielson Company, and United Air Lines. In United Air Lines alone more than 160 radio technicians have been enrolled with CREI at company expense. Hundreds of letters have been received by CREI from leading employers in the radio industry thanking us for notifying them of the study progress of men in their organizations. Hundreds of promotions have been directly credited to such progress.

*Yes*, you will get recognition but only as you study, make satisfactory progress and graduate. *That is distinctly up to you.*

Is home study work? Of course it is work. In this world what you get for nothing is worth exactly that much to you. You will get out of your CREI course exactly what you put into it in real effort. But—after you complete your course you will profit from the increased professional *knowledge all the rest of your life.* You will profit many times over from the effort you devote to professional self-improvement.

Also let us get one thing straight. CREI WANTS YOU TO COMPLETE YOUR COURSE AND GRADUATE. The biggest asset we can possibly have is a large group of successful graduates going up in the radio industry year after year to positions of greater and greater importance. Then you, and many more like you, will recommend CREI to the young fellows following in your footsteps. You will benefit by those who have gone before you into important positions. We want you to study regularly, to graduate, and to be successful in your profession. We will do everything we possibly can to help you whenever you need it.

The first—and possibly the most important—step toward your goal is to complete the first study assignment and send the examination in for grading. You should set a definite time goal for this first one. And then for the next—and then the next—etc. But this first one is the most important. After you have that behind you, you will have a first feeling of accomplishment—and the next assignment will come much easier.

So let us get down to brass tacks and see how to go about it. I am going to give you a few pointers on our service and your steps to success. Get this clear in your mind and then dig right into the first assignment, write up the exam, and get it in the mail to me as soon as you can. Now for the pointers:

1. HOW TO STUDY: THE MOST IMPORTANT FACTOR IN HOME-STUDY WORK IS REGULARITY. You should allot a certain amount of time each day for the study of your CREI course and maintain that schedule. Forty minutes daily is usually much better than eight hours one day per week, although the latter figure represents almost twice as much study time. You should not study too long at any one session. Study means concentration, which is hard and exacting work. When a point is reached where your mind refuses to concentrate on the assignment, stop the study session at once; you will not

gain anything by further work. Several readings at different times will bring out points that were not clear to you or that passed unnoticed at the first reading.

Do not spend too much time on a troublesome point. If you do not understand a point after a reasonable amount of effort, drop it temporarily and proceed with the remainder of the assignment. Quite often the additional information obtained in this way will clear up the difficult point.

It may be of great help to use a pencil and scratch pad. Jot down briefly the important points. Underline important points in the assignments for your own reference. Sometimes a carefully kept personal notebook will help. Keep the longer formulas in it so they will be available for immediate reference.

After studying over a particular paragraph, if there are any points that remain vague, try to put the doubtful points into clear questions. Very often, a review of the several preceding pages on the same subject will help to answer your questions. Often other questions will clear up as soon as you get further into the subject. Keep a list of the questions on points which do not become clear and, when convenient, refer them to your instructor. When you receive the answers go back to the original subject and make sure it is clear. If not, ask for more help. Your questions will help us to understand and help you. Don't memorize a formula but try to understand what it means. Then remember where to find it when you want it. Keep a notebook with the information you expect to use in a handy reference form.

Frequent review is recommended. The mind has a certain tendency to discard some of the material studied. Unless the material is thoroughly learned much of it may be forgotten. If you will make it a habit to review at frequent intervals you will find the following studies have more meaning. Review is much easier than the original study.

During your review you have the advantage of more advanced knowledge from which to draw.

Many students imbued with the idea of haste omit this review and yet the time spent on it may double their knowledge. Actually it will save time in the long run because the more thorough the knowledge of earlier assignments the easier it is to master the advanced assignments.

Don't study theory for the sake of theory alone. Try to make use of the assignments in a practical way. In your employment in the radio or television industry, examine and analyze the equipment around you. Check circuit diagrams when available. Try to formulate your own reasons for the use of certain circuits and circuit constants. Television and radio equipment is designed, not thrown together. Each part is chosen for a specific purpose. Take advantage of every opportunity to study equipment and circuit constants. Catalogs and current radio magazines are also valuable for extra information and practical information.

2. OVERCOMING DIFFICULTIES: If you have any real difficulty with any part of an assignment write to me at once, explaining, to the best of your ability, the *exact nature* of the doubtful points. In the case of problems, please submit your *work* to indicate your method, and how far you are able to proceed. In this way misunderstandings will be cleared up quickly. You are entitled to this service and it is urgently requested that you make use of it rather than delay the completion of your assignment.

Your requests for information should be on separate sheets from your examination when they are submitted together. Similarly, letters on any subject should preferably be on separate sheets for ease of handling. Put your *name* and *student number* on *all* letters and correspondence. Better service can be given if you follow these suggestions.

3. EXAMINATIONS: Study each assignment thorough-

ly. If you cannot answer seventy-five per cent of the questions clearly without reference to the text material, then the assignment needs more study before you start the examination.

Use one of the small forms supplied to you for each examination. Fill in your name, student number, and the address to which you wish the examination returned. Your student number should be placed at the upper right corner of *each* examination sheet. To avoid loss of the examination in the mail *be sure to put your return address on each examination envelope.*

To make it easier for you, use the printed examinations to avoid copying the question and errors that may occur in the process. Some examinations are designed to be answered on the examination sheet and should be used as will be explained. In cases of multiple choice questions, underline the correct answer. Fill in the blanks where they occur with the correct answer. Diagrams should be completed on the original form. For the problem solutions necessitating additional space, we suggest the use of blank paper such as is furnished with the examination. Some examinations may require the use of blank paper for all the answers, and here we ask that you submit the examination sheet for identification and aid in correction. This also saves copying the question on your paper which may be valuable time saved for you.

A neat well-written examination is desirable for aid in writing reports and for later reference notes as part of your course. I would use pen and ink or typewriter in writing up examinations. *Pencil should not be used* because the writing often becomes illegible and is not very neat or impressive to show your friends. For legibility use only one side of light-weight paper. Both sides of heavy paper should preferably be used to save you postage.

The final examination is mailed near the completion of the course. This examination provides the stimulation you need for a thorough review.

4. GRADING SYSTEM: Examinations are graded on the basis that 70% or over is passing, and marks below 70% require a repetition of an examination on that assignment. I hope you won't have to repeat any work.

A good engineer is methodical and exercises great care and neatness in his work. It is my desire to encourage these traits.

Examination papers are graded and returned to you promptly, usually within 48 hours after being received by the school, except on weekends and holidays. Unavoidable delays in the transportation of mail may cause variations of several days in the return of your examinations in some instances. Allowance should be made for delays when correspondence takes longer than you normally expect.

5. POSTAGE REQUIREMENTS: Five sheets of this size paper and one envelope weigh less than one ounce and require three cents postage anywhere in the United States. If you use more paper it will require additional postage at the rate of three cents per ounce. If sufficient postage is not used when mailing your examination it may be delayed several days in reaching the school.

6. SEQUENCE OF ASSIGNMENTS: Study your assignments in the proper order. Years of experience are behind the sequence of assignments, and maximum benefit can be obtained from your CREI course only if you follow the order furnished. Assignments are ordinarily forwarded in groups of five (or more); new groups being forwarded when our records show the student has 3 assignments remaining on hand. Recognition is given to the time required for delivery by mail to different destinations and to your rate of progress. Assignments are being revised constantly, and the foregoing method allows you to receive the most up-to-date edition.

If you expect to be travelling over an extended period of time, where no permanent address can be given, it is suggested that you request an additional group of assignments to avoid running short of study material. You may progress with your studies as rapidly as your abilities and available time permit, but do not sacrifice accuracy for speed. Nevertheless, students frequently complete their studies ahead of their agreed upon schedule of payments.

7. INFORMATION: For information not relating to your studies write to the Director of Student Service. Write to the Chief Instructor concerning your studies.

8. CHANGE OF ADDRESS: Please notify us immediately by separate letter of any permanent change of address so that your letter may be more easily routed to all departments.

9. OUR POLICY: The idea back of the entire CREI organization is service to our students. We want YOU to feel free to ask for help or advice at any time, and as often as you feel the need for it. Suggestions or constructive criticism from the student's viewpoint are always welcome.

10. A "Polyphase Slide Rule" is given to you as a bonus upon satisfactory completion of all the regular examinations and of the final examination.

## SAMPLE EXAMINATION SHEET

Student No.______

Ques. 1. Question may be written out briefly. Include examination question sheet with all examinations. Use the sheets where space permits a complete answer rather than separate paper.

Ans: (a)

(b)

(c)

(Allow sufficient space for the instructor's comments such as a wide margin or space between questions.)

### RECOMMENDED METHOD OF SUBMITTING PROBLEM SOLUTIONS

Ques. Given: L = 160 µh, F = 550 kcs, R = 100 ohms, series circuit.

Find: $X_L$ and Z.

$$X_L = 2\pi FL = 6.28 \times 550 \times 10^3 \times 16 \times 10^{-5} = 552 \text{ ohms}$$

$$Z = \sqrt{R^2 + X_L^2} = \sqrt{100^2 + 552^2} = \sqrt{10{,}000 + 304{,}704}$$

$$= \sqrt{314{,}704} = 561 \text{ ohms}$$

In the case of multiple choice questions underline the correct answer (or answers).

Example: A radio receiver is noisy when (tuned to a strong local station, tuned to a very weak station, the volume control is at the lowest output setting).

The second answer is underlined as the student's choice of an answer.

A blank is to be filled in for the answer in some cases.

Example: Vacuum tube emitters are operated at very________ temperatures.

Fill in the blank with "high," Several words or sentences may be required for some answers where a blank occurs.

(Pages following the first page need your student number and the page number for identification.)

(Any questions on the assignment should be on a separate sheet included with the examination and not among the examination answers.)

Adhering to the above form will greatly facilitate our work with you and permit better all-around service.

- TABLE OF CONTENTS -

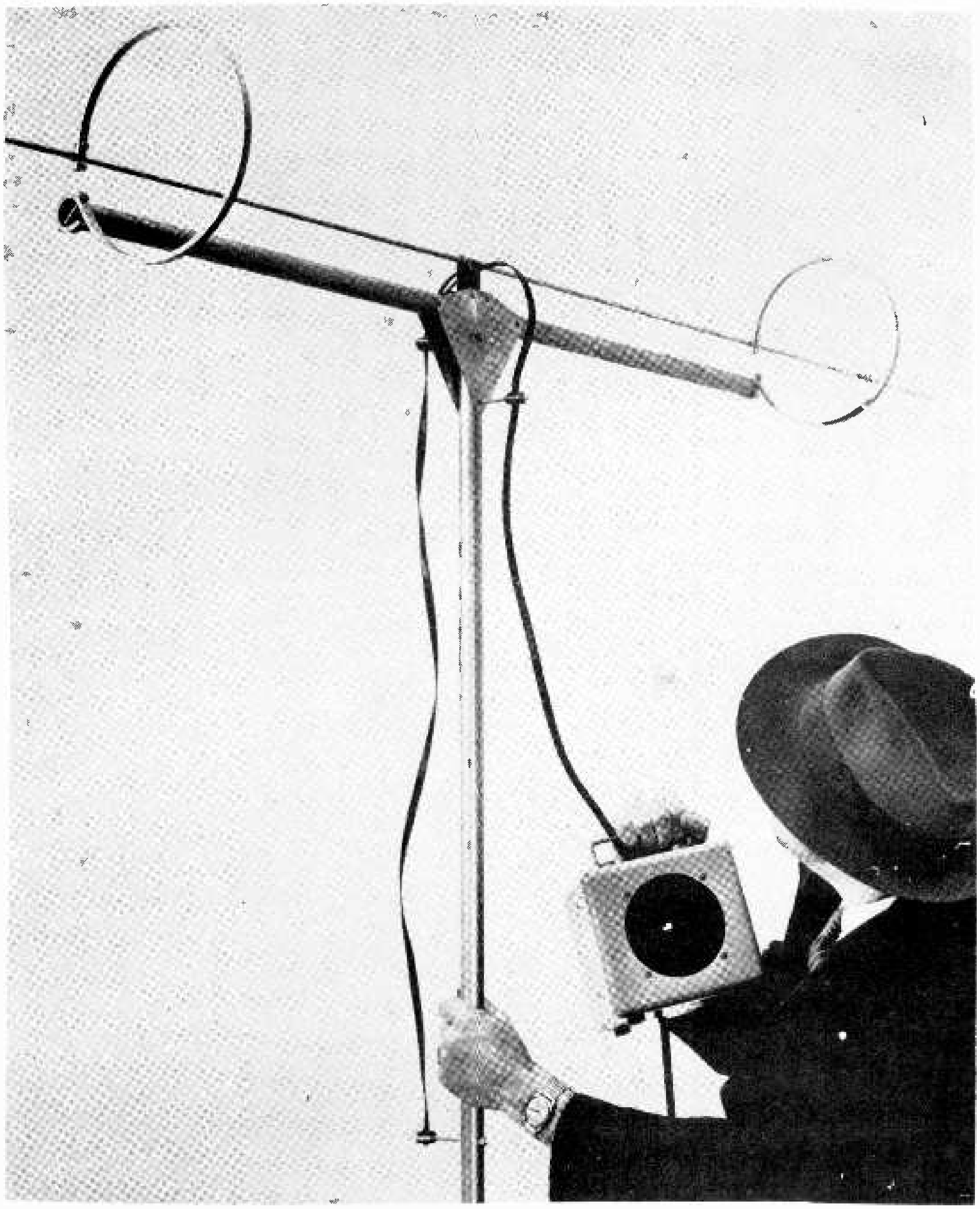
TELEVISION TECHNICAL ASSIGNMENT
FUNDAMENTAL IDEAS

# SPECIALIZED

# TELEVISION

# ENGINEERING

Capitol Radio Engineering Institute
Washington, D. C.



*(Courtesy Raytheon-Belmont Co.)*
Antenna alignment communicator. Service engineer is adjusting antenna and talking over intercom system to co-worker making adjustments on television receiver.

# TELEVISION TECHNICAL ASSIGNMENT

## FUNDAMENTAL IDEAS

### RELATION OF TELEVISION TO RADIO

Just as the radio broadcasting engineer deals with the pick-up, dissemination by radio, and reproduction of sound waves, so does the television engineer deal with the pick-up, dissemination by radio, and reproduction of light waves.

*STUDIO AND TRANSMITTER PROBLEMS.*—Radio transmission problems, whether aural or visual, may be divided into two general classifications—studio and transmitter. In aural broadcasting, the studio engineer must be thoroughly familiar with the properties of sound. He must know the nature of sound, the range of audible frequencies, the manner in which sound is absorbed and reflected by various types of surfaces, and the range of sound intensities which must be handled. He must also have a good understanding of the characteristics of the various types of microphones, amplifiers, attenuators, and other devices by which the sound waves are converted into electrical impulses and controlled. In addition he must be familiar with the characteristics of the human ear.

The television studio engineer has similar problems. He must be thoroughly familiar with the properties of light. He must understand the nature of light; he must know the range of visible light frequencies, and must in addition understand the properties of light waves beyond both ends of the visible spectrum. He must be familiar with the light absorbing, reflecting and refracting properties of various surfaces. He must have a good knowledge of optical systems, lenses and mirrors, and of the manner in which the human eye functions. He must thoroughly understand the range of light intensities and the effects of various intensities on the photoelectric pick-up devices. His job is to convert a wide range of light intensities into a similar range of electrical impulse amplitudes. In addition, since television broadcasting will be accompanied by sound broadcasting, he must also have all the experience and background of the sound engineer. Thus a good television studio engineer should have the combined qualifications of a photographer, an illumination engineer, a sound engineer, and an optical expert, in addition to a thorough knowledge of all types of photoelectric devices, cathode ray tubes, scanning devices, wide range amplifiers, and the many other purely technical aspects of television.

At the transmitter, the television engineer has all the problems of the aural broadcasting engineer plus the special problems relating to ultra-high frequency transmission, such as special tubes and circuits, transmission lines and radiators, line-of-sight transmission, shadows, etc.

Thus to be a competent television engineer, it is first necessary to be a thoroughly experienced radio engineer, and then to specialize in the handling of the various special problems relating to visual transmission.

### PROBLEMS OF TELEVISION

In the commercial sound broadcasting of any program there are three principal factors involved:

First, the technical problem of sound pickup and conversion to electrical impulses, the broadcasting via radio, and the subsequent pickup at the receiver and the reconversion to sound impulses; second, the technical problem of transferring the program from the studio to the transmitter or often to a number of transmitters, some of which may be hundreds or thousands of miles away; third, the development and production of adequate program material. All three of these factors are in a high state of perfection.

*PROGRAM PICKUP.*—The same three factors predominate in television and, logically enough, the first problem of technical pickup, broadcast and reproduction of the visual program has received the major consideration of engineers because without it, the other factors are of no consequence. Millions of dollars have been spent during the past ten years in advancing the technical program of television and tremendous strides have been made. During that time television has advanced from the blurred 60-line poorly lighted flickering picture to the 525-line picture which will compare favorably with the ordinary home motion picture in quality. However, there is still a tremendous amount of work to be done along technical lines before the quality of television transmission and reproduction can compare with that of sound broadcasting.

*PROGRAM TRANSMISSION.*—The second problem, that of transmitting the visual program to a chain of stations, is a very difficult one to solve satisfactorily. Unlike the aural signal, the television signal, due to the *very wide* band of frequencies involved, cannot be transmitted over the ordinary telephone line. Technically, the solution to this problem is not particularly difficult; two practical methods of handling it are at present available: First, the coaxial cable developed by Bell Telephone Laboratories. Such a cable, already installed between Washington, Philadelphia, and New York City *at a cost of more than a million dollars*, will handle a band of frequencies of more than 1,000,000 cycles. By suitable changes in the repeater and terminal circuits this frequency range can be increased. Such a cable will also carry more than 200 simultaneous telephone conversations. The cost of covering the country with such a circuit is staggering, without even considering the cost to the broadcasting company which would lease the equivalent of two hundred telephone lines for a single television program transmission. The other line of attack is to provide ultra-high frequency radio relay links between all cities which are to be on the broadcast chain. This plan is entirely feasible technically, but the cost of providing an adequate number of channels and sufficient apparatus to assure continuous uninterrupted service would be great. An ultra-high frequency circuit for the handling of high speed facsimile transmission is now in operation by R.C.A. between New York and Philadelphia. Both plans are receiving serious consideration.

*PROGRAM MATERIAL.*—A third plan, sponsored by Westinghouse, is to broadcast from an aeroplane flying continually in a circle about 25,000 ft. above the earth. It is called *Stratovision*, and enables a transmitter of about 250 watts to cover a circular area on the earth of a radius of about 240 miles: The results are being watched with interest by the television industry. The third problem, a continuous supply of adequate program material, is among the most difficult to solve satisfactorily. Where a person will listen to, and enjoy, the same piece of music over and over again, he will not look at the same stage show or motion picture more than once. This will call for a continual source of *new* material. In sound broadcasting, performers read their lines from script and a few hours of rehearsal is sufficient for even the most elaborate presentation. In contrast, a theatrical performance is rehearsed for weeks before opening night. It then plays for months to a new audience of a few hundred persons each performance. A television performance can play only once or twice to a nationwide audience and, to maintain the illusion, script cannot be used. The *lines must be memorized* and the *action rehearsed until perfect*—for one performance! The cost of such production would be tremendous. One thinks at once of motion pictures for a steady source of program material. If *all* the feature pictures made by *all* the studios during a year were available for television broadcasting, there would not be enough to assure a continuous supply of new material for one broadcast each day. The U.S. Department of Commerce estimates that if every foot of film produced in America, plus every foot imported, were used for television broadcasting, there would be enough material to supply a maximum of three hours of entertainment each day, provided, of course, that each picture was transmitted but once. Still the radio industry cannot expect to sell high-priced television receivers to the public in large quantities until an adequate supply of *good* programs can be assured. This is one of the most difficult problems still to be solved.

*RECEPTION PROBLEM.*—In connection with the program problem arises another problem which is not present in sound broadcasting. In the reception of a sound broadcast, the complete attention of the listener is usually not required. Various members of the family may be carrying on their ordinary pursuits, reading, playing bridge, working, etc., and still enjoy a musical broadcast. This is not true in the case of television. To enjoy a television program it will be necessary to give it undivided attention. In addition, just as in a theatre, to obtain good results a darkened room will be necessary. Thus for the members of a family to enjoy their mutual society and at the same time a television program, everything else must be put aside, the room darkened, and the entire attention given to the program. It is still an undetermined question whether the average family will be willing enough to do that to give the sale of television receivers at $200 or more sufficient volume to make the entire

Program Material.

enterprise a paying proposition.

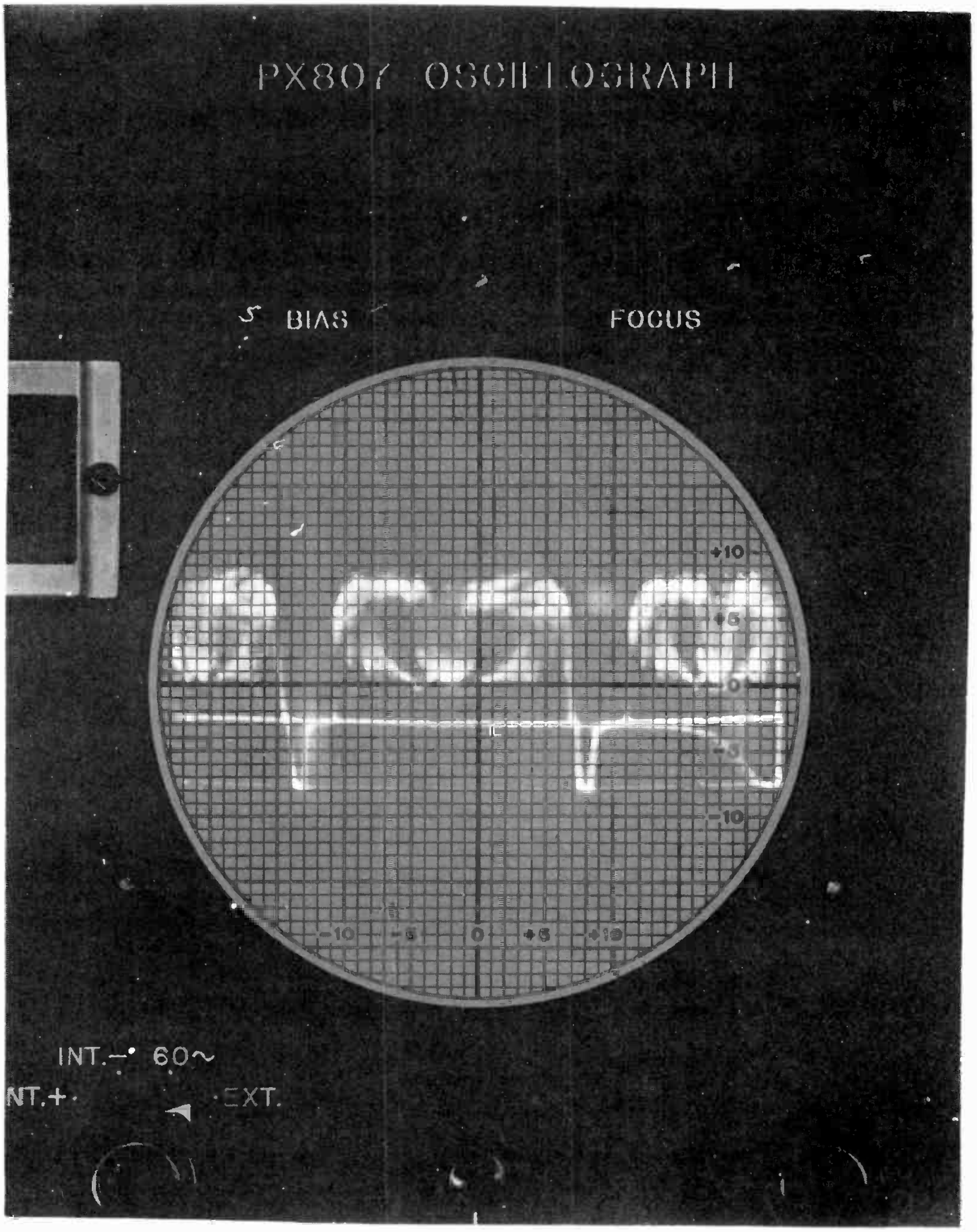
*OBSOLESCENCE AND STANDARDIZATION.*—Another technical problem assumes large proportions in all commercial television plans—the problem of obsolescence. This is a minor problem which solves itself in aural broadcasting. The oldest broadcast receiver ever built is technically capable of receiving and reproducing—in at least an intelligible manner—the most modern broadcast program. This is not true of television. If transmitter and receiver manufacturers standardize on 525-line interlaced 30 frame per second scanning, any subsequent deviation from this standard to further improve the picture quality will necessitate major changes in every receiver or the purchase of new receivers. Thus, there is the danger that too early standardization to make the commercial broadcast of television possible, will freeze the art at some inadequate level and greatly delay the time at which really high quality pictures may be broadcast.

In beginning the study of the technical phases of commercial television, the engineer should be thououghly familiar with the related problems. The problems as outlined above can and will be solved. The best minds of the radio and entertainment industries are intensively working on them. Large scale television which solves in a satisfactory and practical manner all the problems as outlined above will create a great new industry and will provide thousands of positions for those men who are able to make a real contribution to any phase of the problems of production, transmission, or reception of high quality programs. Of infinitely greater importance than learning the operation of any one particular circuit or piece of apparatus, which tomorrow may be obsolete, is a thorough understanding of the principles involved and the methods by which the various problems are approached.

## TELEVISION AND FACSIMILE

To have any real understanding of the methods by which the problems relating to television have been attacked, and the lines along which progress has been made, it is necessary to know something of the background of the present-day television experimental work.

The principles of visual transmission and reception are not new. As far back as 1847 systems were experimentally developed for the reproduction, over telegraph wires, of a sketch or picture. The actual apparatus was very crude but in principle it had much in common with the facsimile (picture transmission) systems in use today. Everyone is familiar with the newspaper reproductions of pictures taken a few hours before and thousands of miles away, and transmitted over radio and/or telephone wires for printing, long before even the fastest airplane could bring a copy of the original photograph. Such picture or facsimile transmission contains most of the elements of television except the necessary speed. If such pictures can be reproduced rapidly enough and in such rapid sequence that the eye retains a vision of one picture until the next one is




Typical television signal as shown on Philco Test Oscillograph. The video intelligence is above the zero line, while the synch pulses are below the reference line.

shown (as in motion picture projection), then the principles of facsimile transmission become the principles of television, the only essential difference being in the rate of transmission.

Some engineers believe that, due to its greater simplicity, facsimile reproducing apparatus for attachment to the home broadcast receiver may precede commercial television. In order that the problems of both may be understood it is well to first consider facsimile transmission.

*PRINCIPLES OF FACSIMILE TRANSMISSION.*—One of the early facsimile systems had much in common with the systems used today. It consisted simply of two metallic cylinders rotating at constant and equal speeds, and connected together electrically, one on each end of a telegraph line. The return circuit was made through a metal stylus over each cylinder. The path of each stylus over the cylinder was a spiral similar to the path of the needle over the old cylindrical phonograph record. A design was drawn on the transmitting cylinder with some insulating material such as shellac. As the stylus passed over this insulation the circuit was broken and the current ceased to flow. The receiving cylinder was covered with a paper saturated with a solution that changed color with a passage of current through it. Thus, the opening and closing of the circuit at the transmitting cylinder would reproduce the design on the covering of the receiving cylinder if the two cylinders were revolving at a constant speed and if both cylinders were started at the same position under the stylus at the same time.

This early attempt to reproduce a drawing was not fundamentally different from the more modern systems for reproducing photographs and other facsimile transmission both by wire and by radio. While the early systems were extremely crude and only line drawings could be reproduced very slowly, the principles of facsimile and television transmission were there: First, the picture to be transmitted was "scanned" electrically, that is, an electrical contact was successively made at regular points over its entire surface; second, a similar electrical contact was made over the surface at the receiving end in the same form; third, accurate synchronism was required. By "synchronism" is meant that the two cylinders rotate at exactly the same speed and that *the positions of the contact points on their respective cylinders are identical at all times.* The two cylinders could be revolving at the same speeds but one stylus could be started at the end of its cylinder and the other stylus at the middle of its cylinder. The speeds of rotation would be the same but the two would not be in synchronism. A schematic sketch of such a system is shown in Fig. 1.

In comparing this early system of facsimile reproduction with the modern systems the major changes have been in increased speed of reproduction and the amount of detail in the completed picture. The increase in both speed and detail is accomplished by the use of a light beam instead of the stylus to move over the picture to be transmitted.

At the transmitting end the picture to be transmitted is placed over a transparent cylinder and a strong beam of light is caused to pass through it and on to a "photocell". (The photocell will be described in detail later; it is sufficient at this point to state that the electric current through the photocell circuit varies with a variation of the intensity of a beam of light shining on the active material.) As the cylinder revolves and at the same time moves parallel with its shaft the ray of light moves in a spiral over the entire picture. As the ray passes through the light and dark portions of the picture its intensity varies with each varition of light and darkness in the picture, causing corresponding variations in the current through the photocell circuit. These current variations are amplified and transmitted by wire or radio to the receiving equipment. At the receiving end the variable electrical impulses are converted back into a light beam of variable intensity which is directed on to a photographic film rotating on a cylinder similar to the cylinder at the transmitting end. Capt. Ranger of the Radio Corporation of America developed such a system that is in use on the Trans-Atlantic radio circuits. The Bell Telephone System uses a somewhat similar arrangement between the large cities over its telephone circuits.

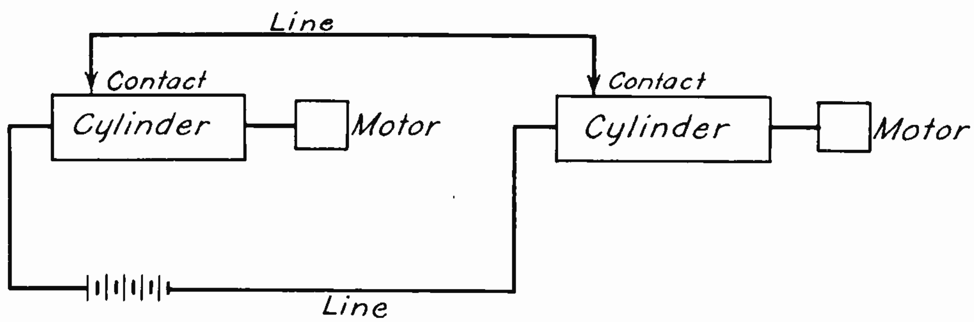



Fig. 1.--Fundamental facsimile system.

The principal difference between the R.C.A. and the Bell systems at the transmitting end lies in the method of arranging the apparatus. In the R.C.A. system the source of light is within the cylinder and the photocell outside; in the Bell system the positions of the light source and photocell are reversed. With either system a picture of 5 × 8 inches can be transmitted in about four minutes. A schematic arrangement of the relative positions of light, cylinder and photocell is shown in Fig. 2.

One of the most difficult problems to solve in long distance facsimile transmission, particularly in an economic manner, is that of synchronism. It can easily be seen that even a slight difference in the speeds of the two rotating cylinders will completely distort the reproduced picture. In addition to the requirement that the cylinders rotate at the same speed, the light spot at any instant must be at exactly the same position on both cylinders, not on the top of the picture at the transmitter and on the bottom of the picture at the receiver. If the motors rotating the cylinders can be operated from the a.c. power supply the problem of speed is easily solved by the use of synchronous motors, the common power supply keeping them in step. In present-day power plant practice, large sections of the country are tied in together for common frequency control, and where such a condition exists synchronous speed becomes a simple matter. Thus, when broadcasting stations adopt facsimile transmissions of news events, cartoons, graphic advertisements, etc., the transmitter can be synchronized with all the receivers operating from the same commercial power supply and difficulty will be encountered only when the operator of the receiver tunes in some long distance station operating from an entirely different power source.

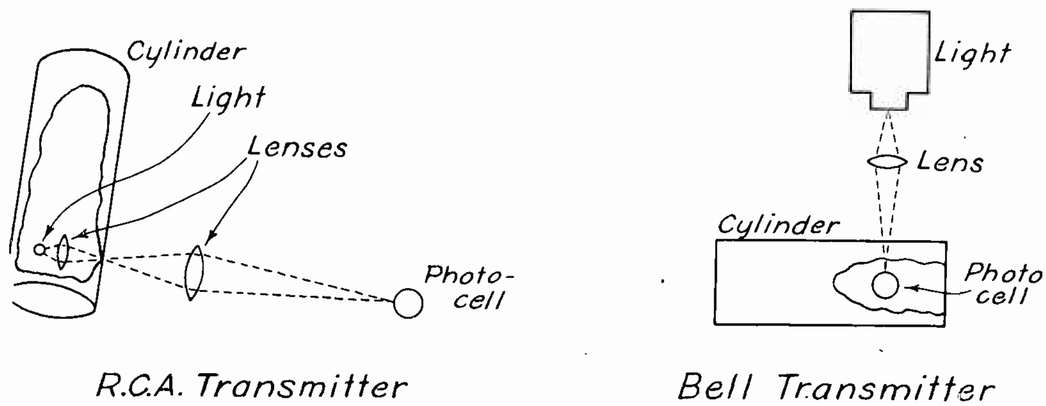



Fig. 2.--**Schematic arrangement of relative positions of light, cylinder and photocell for the R.C.A. and Bell Telephone System facsimile units.**

*APPLICATIONS OF FACSIMILE.*—One very important use for facsimile transmission is the broadcasting of daily Weather Bureau maps to ships at sea. In this case there can be no use of a common power supply and other means must be employed to assure synchronism. One method of doing this is by the use of very accurate tuning fork control, the tuning forks being operated at constant temperature to assure constant frequency.

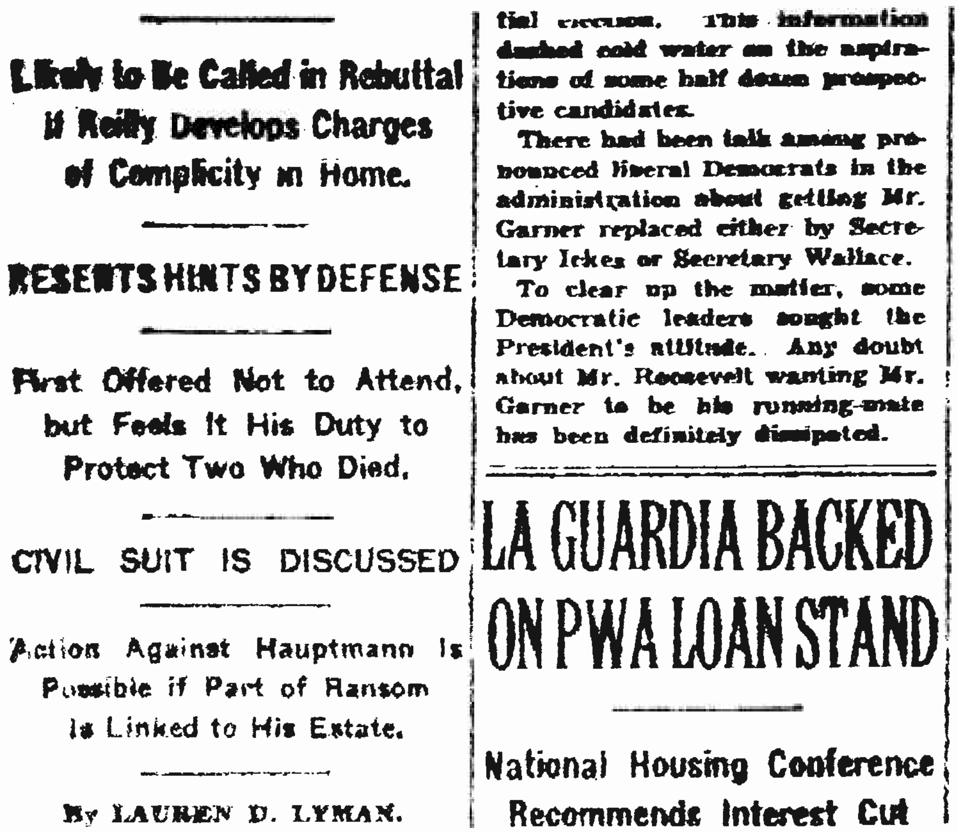
As the standards of facsimile transmission and the speed of transmission continually improve, many engineers predict that this form of transmission will eventually supplant code telegraphy because of the higher speed and greater accuracy with which messages of all kinds may be transmitted as easily as any other picture or design.

In a statement before the Federal Communications Commission as far back as June 15, 1936, David Sarnoff, President of R.C.A., stated, with regard to experimental high speed facsimile communication, "By means of this new development, written, printed, photographic and other visual matter can be sent by radio over long distances and reproduced at the receiving end with amazing exactness. It is difficult to imagine limits to the use of such an invention. It should make the dot and dash system of telegraphy as outmoded as the pony express."

For home reception of facsimile news events, it has been suggested that the broadcasting stations broadcast such material in the early morning hours while regular programs are off. In such event the owner of the receiver will simply leave it turned on when he retires for the night and get his news report in the morning. To make such service practical it will be necessary that all receivers be set at a starting point and all started automatically and simultaneously by a signal from the transmitter. There does not seem to be any great technical difficulty in the establishment of such service in a practical form.

R.C.A. has already developed and demonstrated a very practical facsimile reproducer which could readily be applied to home use and which could be installed quite inexpensively. Instead of a photographic process at the receiving end, a relay operates a stylus which presses intermittently on a carbon paper thus making a mark on a roll of white paper. This device will print on a roll of paper the width of three columns of newspaper type at the rate of one inch per minute with very good quality of reproduction of such material as newspaper copy. In this system a cylindrical scanning arrangement is used at the transmitter but each scanning line is along the axis of the cylinder, the cylinder rotating the width of one scanning line at the end of each line scanned. At the receiver the roll of white paper and roll of carbon paper are rotated the proper amount at the end of each line reproduced across the paper. A reproduction of several inches of newspaper material actually reproduced by this process is shown in Fig. 3.

*TELEVISION.*—While present-day facsimile transmission is a great improvement over the older systems it is still far from television. If it is assumed that for good television reproduction, continuous movement of the object must be shown with no more "flicker" than in a good motion picture reproduction on a screen, an enormous increase in speed over that of facsimile transmission must be obtained. The motion picture is made possible through a peculiarity of the eye called "persistence of vision". The response of the eye to the appearance of light and to its removal are



Likely to Be Called in Rebuttal If Reilly Develops Charges of Complicity in Home.

RESENTS HINTS BY DEFENSE

First Offered Not to Attend, but Feels It His Duty to Protect Two Who Died.

CIVIL SUIT IS DISCUSSED

Action Against Hauptmann Is Possible if Part of Ransom Is Linked to His Estate.

By LAUREN D. LYMAN.

tial election. This information dashed cold water on the aspirations of some half dozen prospective candidates.

There had been talk among pronounced liberal Democrats in the administration about getting Mr. Garner replaced either by Secretary Ickes or Secretary Wallace.

To clear up the matter, some Democratic leaders sought the President's attitude. Any doubt about Mr. Roosevelt wanting Mr. Garner to be his running-mate has been definitely dissipated.

LA GUARDIA BACKED ON PWA LOAN STAND

National Housing Conference Recommends Interest Cut

Fig. 3.--Sample of newspaper page printed by the R.C.A. facsimile receiver.

characterized by a delay or build-up in sensation, it takes time for the full effect of the light to be perceived, and it takes time for the sensation to die out after the light is removed. Thus, if one looks at an object and then suddenly shuts his eyes, the vision of the object still appears for an instant. On the motion picture screen different pictures are flashed in succession at the rate of 24 pictures per second. Rates as low as 16 pictures per second have been used. At 16 pictures per second the picture appears to flicker slightly. At 24 pictures per second the motion of the object shown appears to be smooth and continuous. Actually different pictures are shown on the screen, one after the other, but the eye retains one picture until the next appears with only the difference in the positions of the objects that can occur in 1/24th second. The eye responds instantly to the new picture and during a series of such consecutive pictures the object appears to have a continuous movement. The pictures are jerked rapidly before the observer, the light being cut off for an instant while the picture is changed, but, due to the "persistence of vision", the eye cannot follow these changes and movement appears smooth. In motion picture projection, to reduce flicker still further, the light is interrupted during each picture while it is stationary, so that the actual frequency of light impulses striking the eye is 48 per second instead of 24.

In television the present standard adopted for the number of pictures per second for satisfactory reproduction is 30. This means that to reproduce a moving object on a screen it is necessary, instead of transmitting one picture in slightly less than one minute as in facsimile, to reproduce *30 complete pictures each second.* Thus the speed requirement for television is *many* times greater than for facsimile transmission. (The reasons for adopting a frame frequency of 30 per second instead of 24 as in motion picture practice will be explained later.)

*PICTURE ELEMENTS.*—It has been shown that in order to send a picture from one place to another by wire or radio, some means must be provided for interpreting the details of the picture in electrical impulses. In order to compare two pictures for detail it is first necessary to understand the structure of a picture. Since the picture is to be made up of a number of impulses of different intensity consecutively arranged in lines over the surface of the picture, it may be compared with an ordinary newspaper half-tone. The half-tone is made up of a large number of dots, these dots being formed by printing the picture on a copper plate through a very fine screen. This screen divides the picture up into a large number of parts, each part reproducing according to the light through that one portion of the screen. In a good newspaper half-tone a screen of 100 divisions per inch is used; thus, every square inch of the picture contains 100 × 100 or 10,000 dots of various intensities. To produce the same detail by facsimile transmission the picture would have to be made up of 10,000 impulses per square inch. For a picture of 5 × 8 inches the area is 40 square inches, and on the basis of 10,000 impulses per square inch a total of 400,000 impulses would be required. To reproduce this picture in one second would require 400,000 light impulses per second. For television purposes the reproduction would have to be 30 times as fast, or 12,000,000 per second.

In certain types of television experimental work considerably less detail will give fair reproduction. In a picture of moving objects passing before the eye, the motion distracts the observer and thus makes up for a considerable loss of detail, since the principal interest of the observer is in the action taking place, so that he becomes less critical of small imperfections of detail. (This statement is true only for very crude picture transmission. As better and better pictures are transmitted with greater detail, the effect of motion and interest in the picture in compensating for lack of actual detail becomes less. With high quality of reproduction this effect may be neglected.) Thus, in a simple picture one and one-half inches square considerable detail will be obtained by causing the light to pass horizontally over the picture in 60 straight lines. If the picture has such contrasts that the light varies in intensity 60 times on each horizontal passage, then the number of impulses per picture will be 60 × 60 or 3,600. With 30 complete pictures per second the number of impulses per second will be 3,600 × 30 or 108,000. While this is rapid, it is easily within practical limits. In actual practice the light intensity would not vary 60 times on each parallel line of light, and the impulse frequencies encountered in a picture of this size average considerably less than 108,000 per second. The horizontal lines compare with the number of spirals on the cylinder. The number of impulses per horizontal line compares to the number of impulses on each complete revolution of the cylinder.

In the very early television experimental work where a picture larger than one and one-half inches square was desired, the image was magnified and thrown on a screen in a manner similar to motion picture reproduction, or the picture was viewed through a magnifying glass. In either case, of course, the larger the picture was made for a given number of scanning lines, the coarser it became and the less the apparent detail.

It should not be thought that a picture of the size mentioned made up of 3,600 picture elements will give sufficient detail for any practical purpose. The present experimental standard adopted by the Radio Manufacturer's Association is 525 lines, per picture as the minimum for satisfactory reproduction. For a square picture this would mean $525^2$ or 275,625 picture elements. (actually a square picture is not used, an aspect ratio of 1.33 in which the length is one-third greater than the width being accepted as standard. Thus the number of actual picture elements is even greater. This will be discussed in detail later.)

*SCANNING.*—It has been shown how the ray of light is caused to pass through the transparent cylinder of a facsimile transmitter in a series of spiral paths until it has passed over all points on the surface of the cylinder. The absolute need for synchronism has also been shown; not only synchronous speed but also synchronous position of the light on the cylinder in both the transmitter and receiver.

In television the arrangement of the apparatus is considerably different but the same synchronization is necessary. In television transmission and reception instead of the ray of light of varying intensity moving in a spiral path around the cylinder where the observer could only see one part of the surface at a time, the ray of light (or electron beam—in the modern electronic system) is caused to move in consecutive lines over a flat screen as in a motion picture, or over the fluorescent surface of a cathode ray tube. If a 525-line reproducer is used the light ray or electron beam simply makes 525 parallel horizontal paths across the screen from left to right, each path being slightly below the preceding one, until the entire surface of the picture has been covered. Then the beam starts at the top and again covers the picture in 525 consecutive lines, etc. This is shown schematically in Fig. 4.

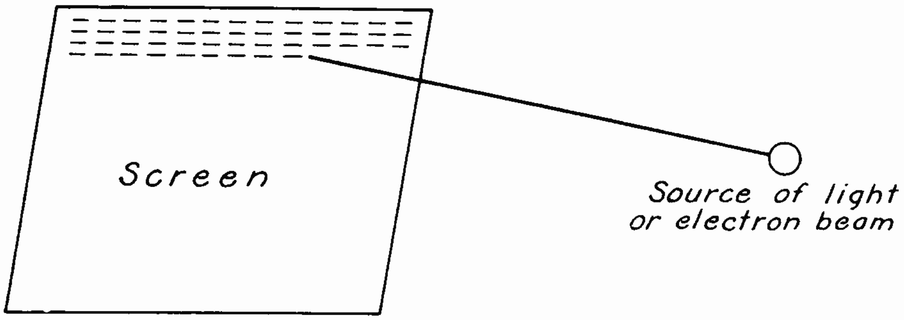



Fig. 4.--Method of scanning a picture in television.

*INTERLACED SCANNING.*—Actually in the present experimental systems the scanning is not quite so simple as this. For reasons which will be explained later, a method of "interlaced" scanning is used. With this system only every other line—1, 3, 5, 7, etc.—is scanned and the entire picture is scanned from top to bottom, 262.5 lines, in 1/60th second. In the next scanning the lines between—2, 4, 6, 8, etc., are scanned from top to bottom in 1/60th second. Thus, every point in the picture is scanned 30 times per second but the actual scanning from top to bottom is at the rate of 60 times per second. For the time being, in order to get a fundamental idea of the problem of scanning, the matter of interlacing may be neglected.

In the discussion of facsimile transmission and reception it was shown that synchronization of speed alone is not sufficient. Even though the ray of light at the receiving end is moving over the screen at exactly the same velocity as the light ray is moving over the object at the transmitting end, if the two light rays do not have the same relative positions at the same instant, true reproduction of the object viewed will not result. Suppose the light ray is moving over the top of the object at the transmitter and the light ray at the receiver is moving below the center of the screen. The object will appear to be cut in two, the top half at the bottom of the screen and the bottom half at the top. Any other displacement in position will cause equivalent distortion at the receiver.

If the beam is arranged (as in Fig. 4) so that it can complete 525 horizontal lines in 1/30th second, each line being a given distance below the preceding line, the screen will be completely covered by the beam in 1/30th second. If the beam at the receiver is caused to vary in intensity in the same manner as the beam at the transmitter, then at the receiver will be reproduced the transmitted picture. The question may be raised: "Why doesn't one merely see a ray of light travelling from one side of the screen to the other and making a small dot of light on the picture?" The answer is that this is all the eye *does* see; but the dot of light moves from one place to the next so rapidly that the characteristic of the eye known as "persistence of vision" will not let the apparent light at one spot die down quickly enough, and the result is that one *appears* to see a glow over the entire screen at once. If the light is going through intensity variations at certain positions those intensity variations are picked up *and retained* by the eye for at least 1/20th second. Within this time interval another picture is being started at the same spot and to the eye the light has not moved. Actually the light may be comparatively intense at any one spot but due to its short duration at each spot the effect is more of a glow. If the figures given above are assumed, 525 horizontal lines, 525 spots per line (assuming a square picture), and 30 pictures per second, the actual duration of the light at any one point per picture is only 1/8,268,750 second. (This assumes mechanical types of scanning.) Looking at it from another angle, any one spot is illuminated for only 1/275,625 part of a picture time. With a small point of light of such brief duration at any one spot, the total illumination from the entire surface cannot be great unless the intensity of the spot is very high. The problem of obtaining a light at the receiving end of sufficient intensity, that can be made to move rapidly, and vary rapidly enough in the proper intensity proportions, has been one of the major technical problems of television. (This problem is not so difficult as the figures shown when using cathode ray reproduction at the receiver. The spot of light on the fluorescent screen does not die out instantly as the cathode ray moves over the surface. In fact the glow may persist for a quite large fraction of a second. Thus, while the fluorescent spot is not nearly so intense as with some other light sources tried, the *amount* of light which is equal to the product of time and intensity may be considerably greater. This is one of the definite advantages of the use of electronic scanning at the receiver. As will be shown later, a somewhat similar effect is obtained at the transmitting end with electronic scanning.)

When the extremely short time intervals involved are considered, it becomes easier to understand the degree of precision with which the television engineer must work. Remembering that the object viewed is moving and that, although actually the light spot is seen at any one point for only an extremely small fraction of a second, the intensity of the light at that one particular point may vary in intensity several times per sec., the immense difference between facsimile reproduction and television will be appreciated.

## FURTHER CONSIDERATIONS IN TELEVISION

*LIGHTING REQUIREMENTS.*—One of the greatest difficulties the television engineer has had to overcome is lack of sensitivity in equipment for first transferring light changes into electrical impulses, and then transferring these back into light variations again. The early photo-electric equipment was so insensitive that it was possible to reproduce only outlines and simple objects, even with the most intense illumination. In some of his early experiments in 1924 in England, Baird used dummy figures because the heat and light at the transmitting end was too intense for living subjects. Two factors have combined to help overcome this difficulty; first, photo-electric devices have been made many times more sensitive; second, the use of lenses to concentrate the light collected has enabled a more intense light beam to be developed from an illumination of lower intensity. By the proper use of lenses and very sensitive photo-electric devices, moving scenes have been picked up outdoors with natural light.

A similar difficulty has been encountered at the receiving end. It has been extremely difficult to develop a light for receiver purpose that can be caused to change in intensity as rapidly as is required for television purposes, and still have sufficient intensity to produce the illumination required for good definition of the moving object. By the development of better lights, special magnifying lenses, greatly improved cathode ray tubes, etc., this problem has been attacked. About 18 years ago the Bell Telephone Laboratories developed a large lamp consisting of 2,500 sections, each section being fed by a separate conductor from a distributor. This produced a self illuminated picture several feet square, but the detail was poor and the principle is out of the question for home use on account of the elaborate apparatus required. The recent developments of large cathode ray tubes and projection tubes appear to be the solution to the problem for home use. A tube having an active fluorescent surface 20 inches in diameter can produce a fair sized image of good intensity and can be made to respond to extremely high frequencies, or a 5- to 7-inch tube producing a small but very intense image can then have this image magnified to the size of a large screen and yet be satisfactorily bright.

The high light intensity is obtained by the use of high anode voltage and large cathode ray current, with a very small beam diameter, this resulting in a very small and very intense fluorescent spot. For home use potentials around 27,000 volts are used; for theatre projection, potentials as high as 60,000 volts are employed. The use of 27,000 volts in the home may appear to be dangerous, but special, ingeniously designed power supplies have been developed that have the characteristic that the voltage drops to a very low and safe value when a heavier-than-usual load is put on them. (The action is similar to that of the old Tesla coil.) Thus, if a person accidentally touches a high-voltage terminal, he draws just enough current to receive a painful but not dangerous—or at least fatal—shock. The projection tube and power supply will be discussed in greater detail in a later assignment.

*ULTRA-HIGH FREQUENCY TRANSMISSION.*—Another serious problem that seemed to have no practical solution until the extremely high radio frequencies (very short waves) were considered for television transmission, is that of the modulation and side band frequencies. Consider a picture having an aspect ratio of 1.33 (ratio of width to height) to be scanned at 525 lines, 30 pictures per second. The maximum number of picture elements is 525 × (1.33 × 525) or 367,500. However, owing to the fact that the spot is normally circular in shape, and that its intensity varies from a maximum at its center to a minimum at its circumference the *effective* number of picture elements is only about 75 per cent of the above value, or 367,500 × .75 = 275,625 elements. Since the picture is reproduced 30 times per second, there are 275,625 × 30 = 8,268,750 elements per second.

It requires, however, two impulses, one light and one dark, to make one electrical cycle. Hence the maximum modulation frequency will be 8,268,750/2 = 4,134,375 cycles or 4,134.375 kilocycles per second. As explained farther on, the process of modulating the carrier wave produces so-called upper and lower side bands, which—for the above maximum modulating frequency—will cover a range or band of from 4,134 kc below to 4,134 kc above the carrier frequency, a total band width of 8,268 kc for one channel. This is more than five times as wide as the entire broadcast band! It is true that there are methods (to be explained later) of compressing the band width to a little over one-half the above value, but it is still in the neighborhood of several thousand kilocycles for each channel.

Since at most ordinary radio frequencies even a low power transmitter has a considerable interference range, and since it is obviously impossible to separate a large number of stations by several thousand kilocycles or to give a band that wide to any one high power station, acceptable television at the previously used radio frequencies is entirely impractical. Even if single side band transmission should be successfully developed, the side band width is still far too high. However, at the ultra-high radio frequencies of 50 megacycles (50 million cycles per second) or higher, corresponding to wavelengths of 5 or 6 meters or less, these limiting conditions no longer exist. In the first place, a side band width of 4,500 kc/s at a radio frequency of 50,000 kc/s is not particularly out of proportion and at such high frequencies there is room for a number of such channels. Second, the transmission range at these frequencies is practically limited to the *visual* distance just as are light rays, and by separating the stations by 200 miles, quite a number of stations may be placed on the same frequency channel without interference.

Therefore television transmission development will certainly be along the lines of very high frequency stations, each city having its own stations, and reception practically limited to the local transmitters. Because of the very high signal level required for good picture reception, it is anticipated that fairly high power transmitters (several kilowatts) will be required for metropolitan centers, even though the transmission distance will not be great. Receivers for such reception will be superheterodynes with the amplifiers capable of amplifying a *very* wide band of frequencies without undue discrimination against any part of the band. The same receiver will be used for both the visual (video) and sound (audio) channels.

The present system has complete television channels 6,000 kc/s wide; each channel includes the visual channel, the sound channel, and guard channels. The arrangement is as follows: Video (visual) frequency restricted to 4,500 kc/s or 4.5 mc, which requires a band width

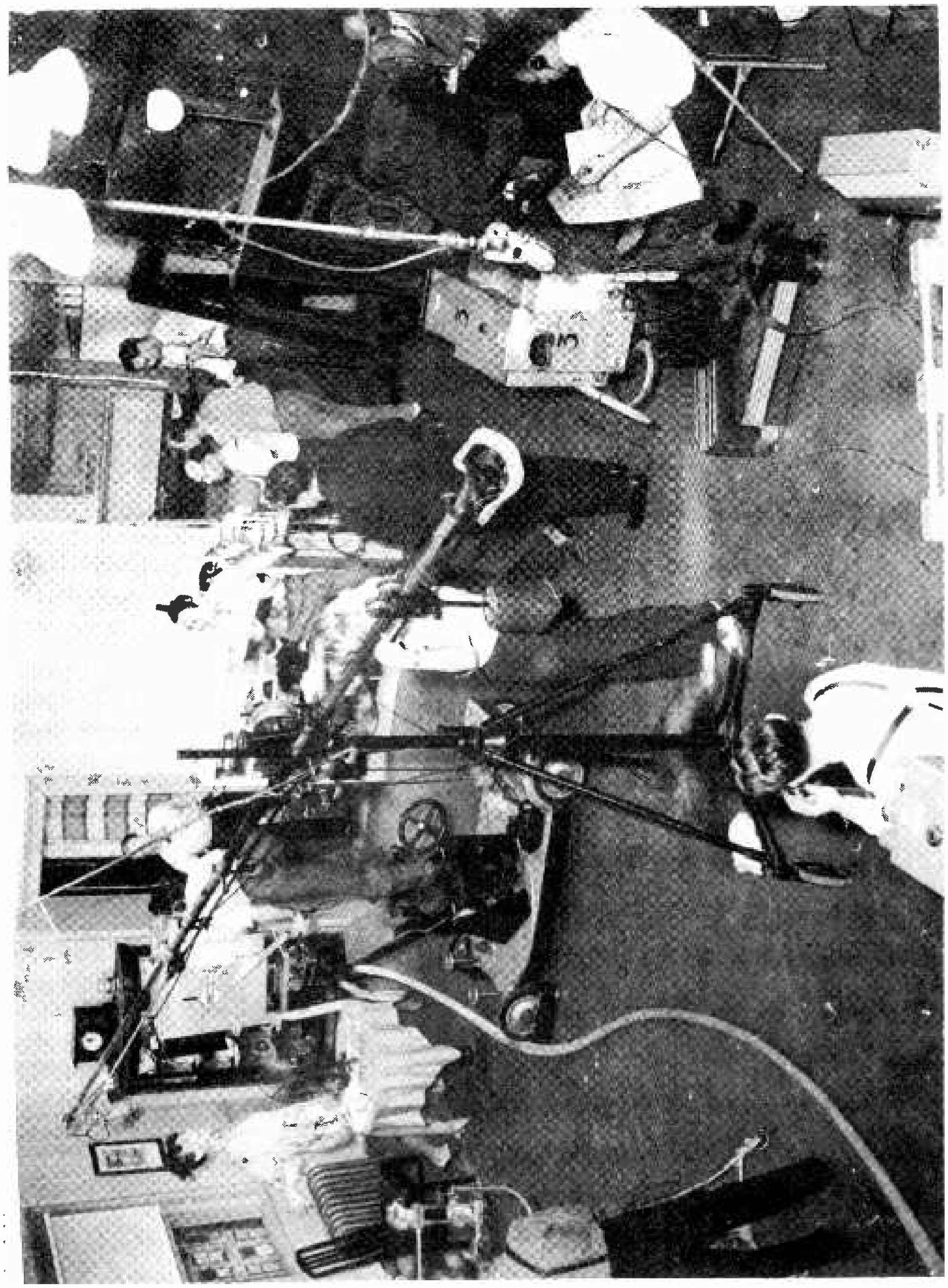


Fig. 5.--NBC Television presented "Lights Out" to televiewers recently.

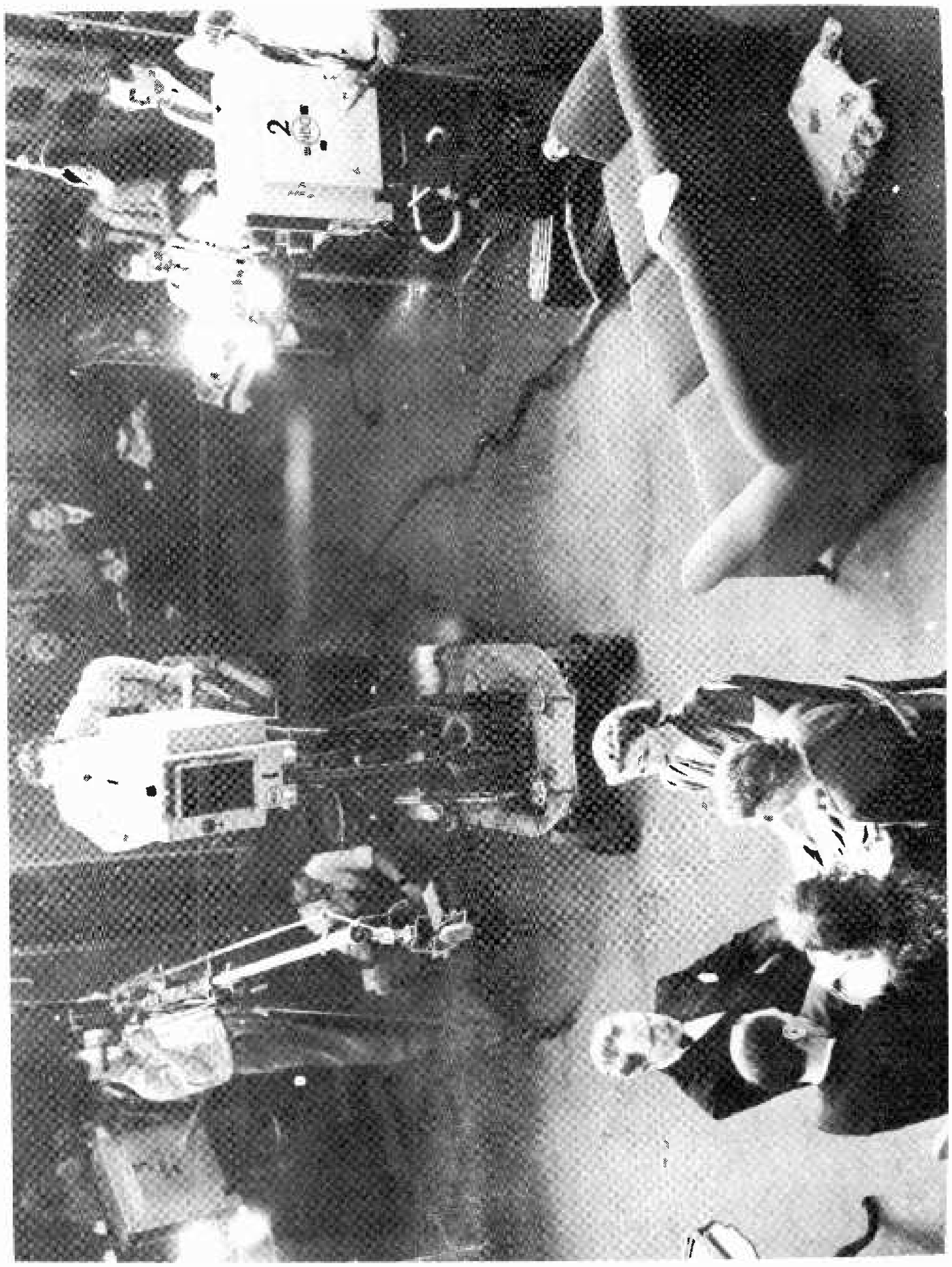


Fig. 6.--A camera on a dolly comes in for a closeup of the cast of "Blithe Spirit" televised over station WNBT, NBC's television station in New York.

or frequency range of 5.75 mc when what is known as vestigial side-band transmission is employed; this includes a guard band or empty space in the frequency spectrum between the video and sound frequencies. An additional 0.25 mc is allowed between the sound carrier and the top end of the band: This takes care of the sound side bands and also leaves a guard space between the sound side bands and the adjacent television channel or station. The sound is broadcast by means of frequency modulation (FM), so that the television engineer must be versed in FM as well as in television.

With such a definite arrangement of frequencies, a single receiver (of the superheterodyne type) can be used to pick up both the sound and picture signals. Although this will be discussed at much greater length farther on in the course, it will be of interest to mention here that the composite signal is changed to one of a lower band of frequencies (called the intermediate frequency) by means of the superheterodyne principle in order to obtain better selectivity and amplification, and then the picture and sound signals are separated by suitably selective circuits (called filters), and each individually amplified an additional amount and finally fed to the loudspeaker or picture tube—as the case may be—in order to reproduce the sound and picture picked up in the studio.

Thus, although ultimately two receivers—picture and sound—are in reality employed, the common amplifier stages at the head end of the receiver permit a design wherein tuning is made very simple. Moreover, only one antenna is required, and the whole receiving system can be made more compact. More recently methods have been developed to utilize a series of pulses used normally for synchronization, to convey the sound, so that no separate carrier frequency is required for it.

This is in line with a new system of communication, called pulse-time modulation, that has been successfully employed by the armed forces in World War II. At present such a method of sound transmission is limited to experimental television systems, such as the color system devised by the Columbia Broadcasting System, but it must not be overlooked that the experimental system of today can very well become the standard system of tomorrow.

*TELEVISION EQUIPMENT.*—Figs. 5 to 11 will give the engineer some idea of the advances made in modern television apparatus. Fig. 5 shows the origin of a television broadcast program—the studio. This picture was taken in the television studio of the National Broadcasting Company in New York City. The studio resembles a sound movie set. Three "Iconoscope" cameras are shown. (The iconoscope is the photo-electric device by which the scene is "scanned", and which converts the light image into a series of electrical impulses. The camera on the "dolly" close to the scene televised may be moved back and fourth while the scene is being "shot", and therefore permits action to be followed, as well as special effects to be obtained.

The camera to the right, as well as the one in the foreground, are mounted on simpler pedestals, but even these have motor-operated devices for raising and lowering the camera containing the lens system, the iconoscope,

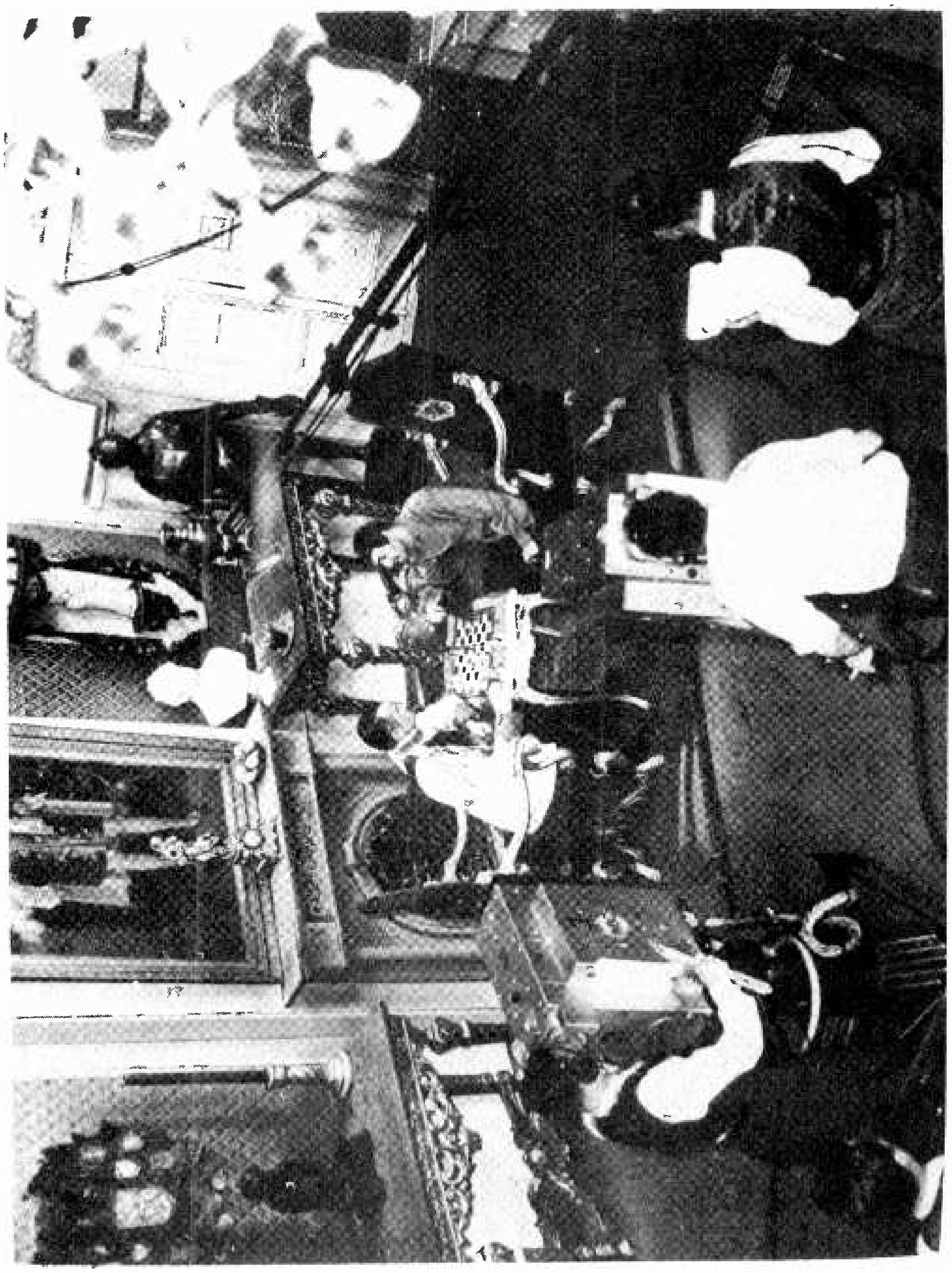


Fig. 7.--In a "Game of Chess," famous one-act play recently presented over NBC's television station WNBT, the cameras are in for a closeup shot of the two principal characters.

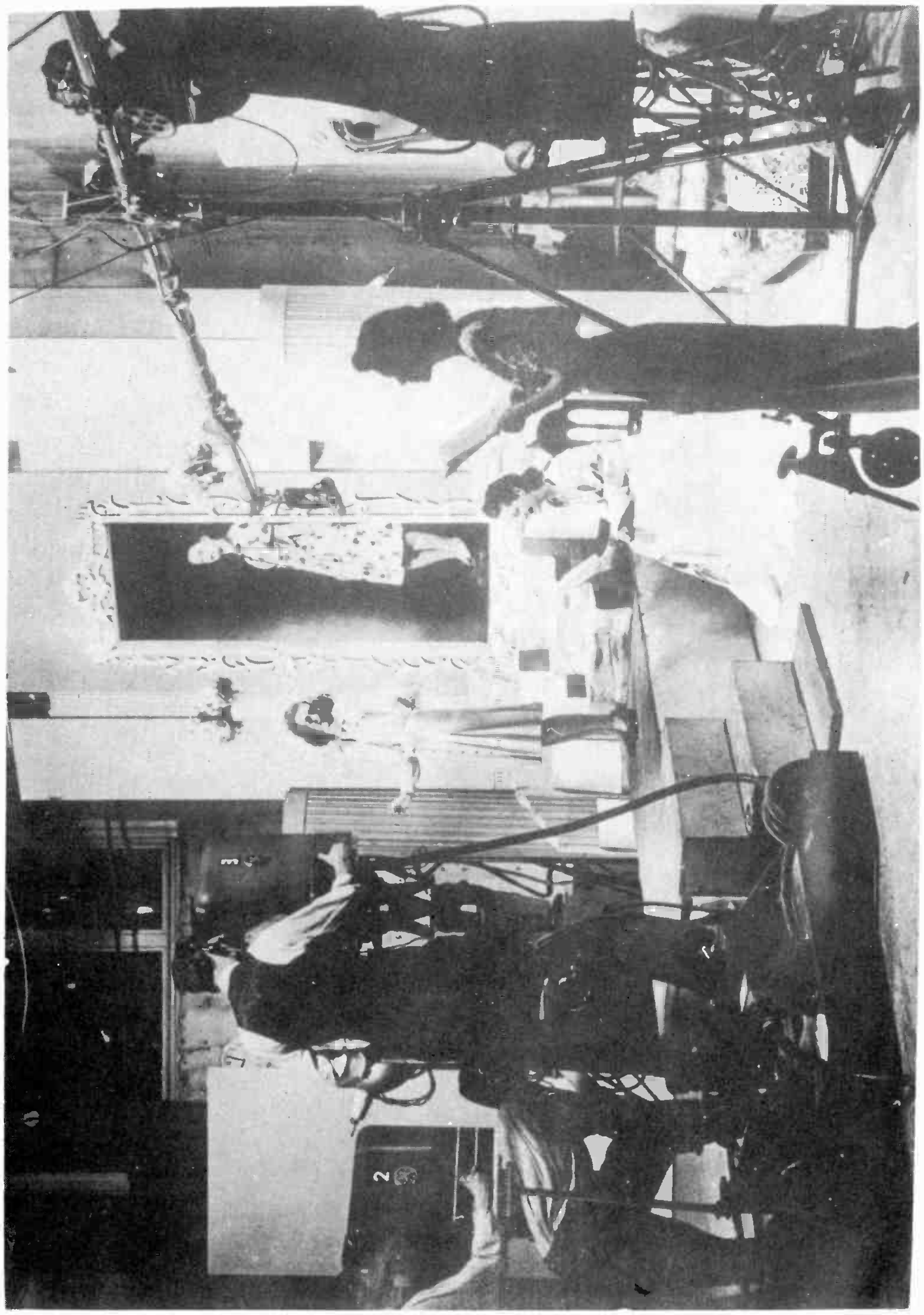


Fig. 8.--G.E. studio scene.

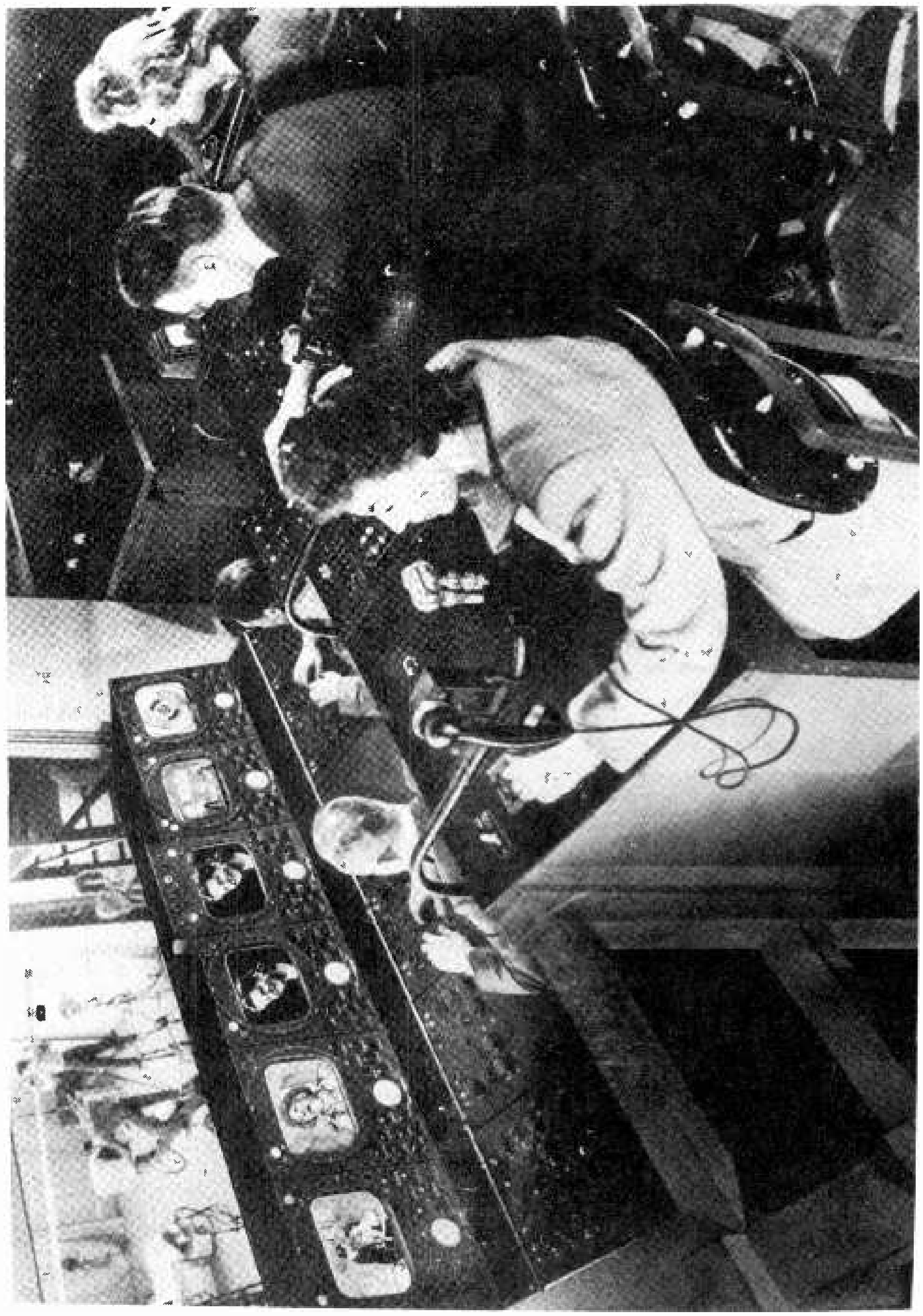


Fig. 9.--Monitors and program directors of G.E. station WGRB, Schenectady.

and its associated "pre-amplifier". The two long handles projecting from the back of the camera are for operating the lens focusing mechanism and the motor-driven elevating device described above.

Note the "Birdseye" type of lamp employed for illumination; banks of these lamps are placed at various points around the scene and overhead to obtain the desired lighting effects. Also note the microphone mounted on a long boom. It can be manipulated so as to be kept close to the performers and yet out of the view of the cameras.

Fig. 6 shows another studio scene as viewed by the performers. Note the lights in banks of four, the heavy, rubber-covered cable connecting each camera with the control room in the rear (not shown), and the other studio sets on the sides and rear, to which the cameras can be shifted for other shots.

Fig. 7 shows another studio scene where the action is for the most part "close-up". Again note the microphone boom with the microphone hanging directly over the players. Also note the banks of light to the right of the scene.

In Fig. 8 is shown a studio at WGRB, the G.E. station at Schenectady. An important difference is the type of lighting employed; it consists of high-pressure mercury arc lights that emit a large amount of light with little heat. One such "luminaire" can be seen directly over the cameraman standing on the dolly.

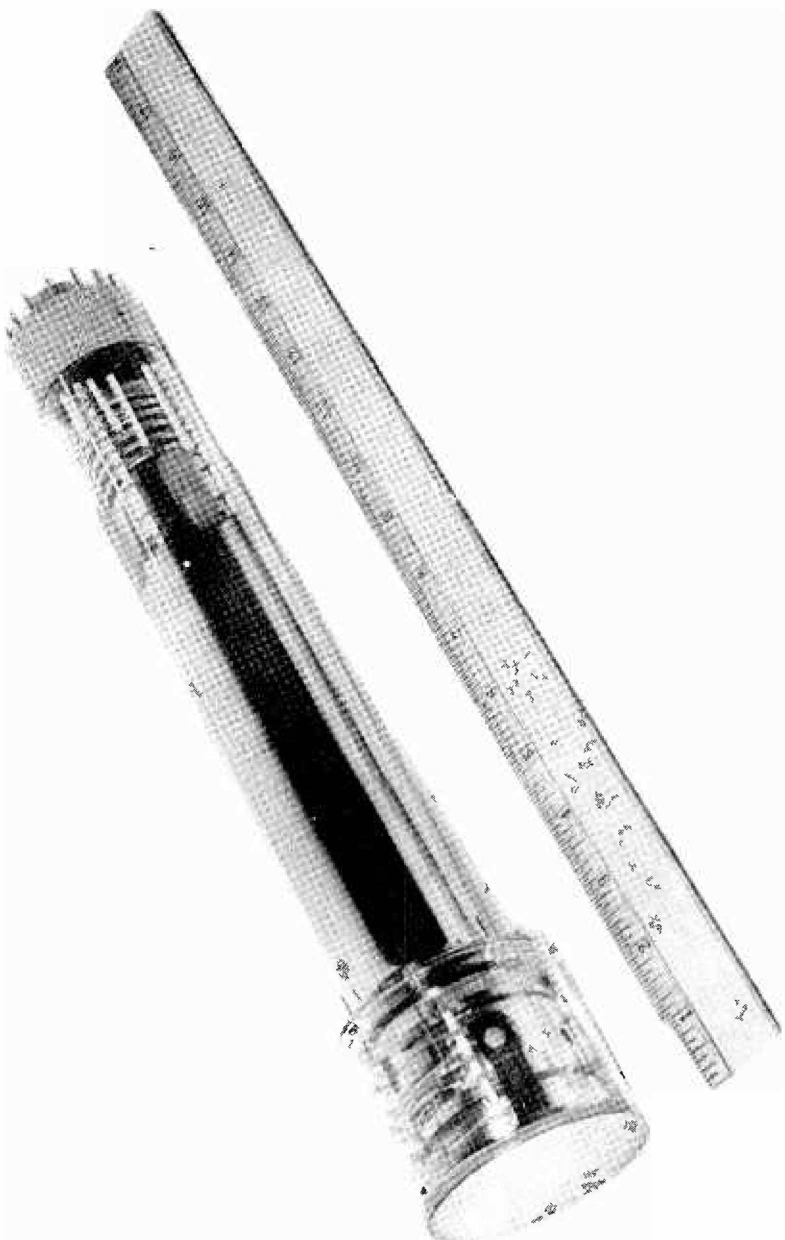
Fig. 9 shows the control room of the G.E. studio. This room overlooks the studio, so that the action may be observed directly as well as on the picture tubes mounted in front of the controls of the console. The picture tubes, called monitor tubes, permit action on several sets in the same or other studios to be observed simultaneously, so that the scenes to follow can be cued beforehand. The three people at the right are from the so-called "production department", they supervise the entire action, both of the performers and of the engineers and technicians.

The pictures all emphasize the fact that a number of engineers and technicians are required to produce even a simple television program. In addition to studio personnel there are other groups who televise outdoor remote scenes. For this purpose, where this is little control of the lighting, a special new pickup tube, the image orthicon, is particularly valuable. This tube has a sensitivity that approaches that of the human eye, and it permits the televising of scenes that would otherwise be impossible to pick up.

Fig. 10 shows the image orthicon tube itself, and Fig. 11 shows its use in the pickup of a baseball game. In Fig. 12 are shown the cameras equipped with this tube and with telephoto lenses, which permit closeup shots to be obtained even though the camera is at a considerable distance from the action.

Fig. 13 shows a modern television receiver of the direct-viewing type; i.e., the image appearing on the front face of the picture tube is viewed directly by the audience. The several control knobs below the picture tube indicate the greater number of controls necessary here as compared to an ordinary broadcast receiver.

Fig. 14 shows several pro-



(*Courtesy RCA*)

**Fig. 10.--Image Orthicon Tube.**

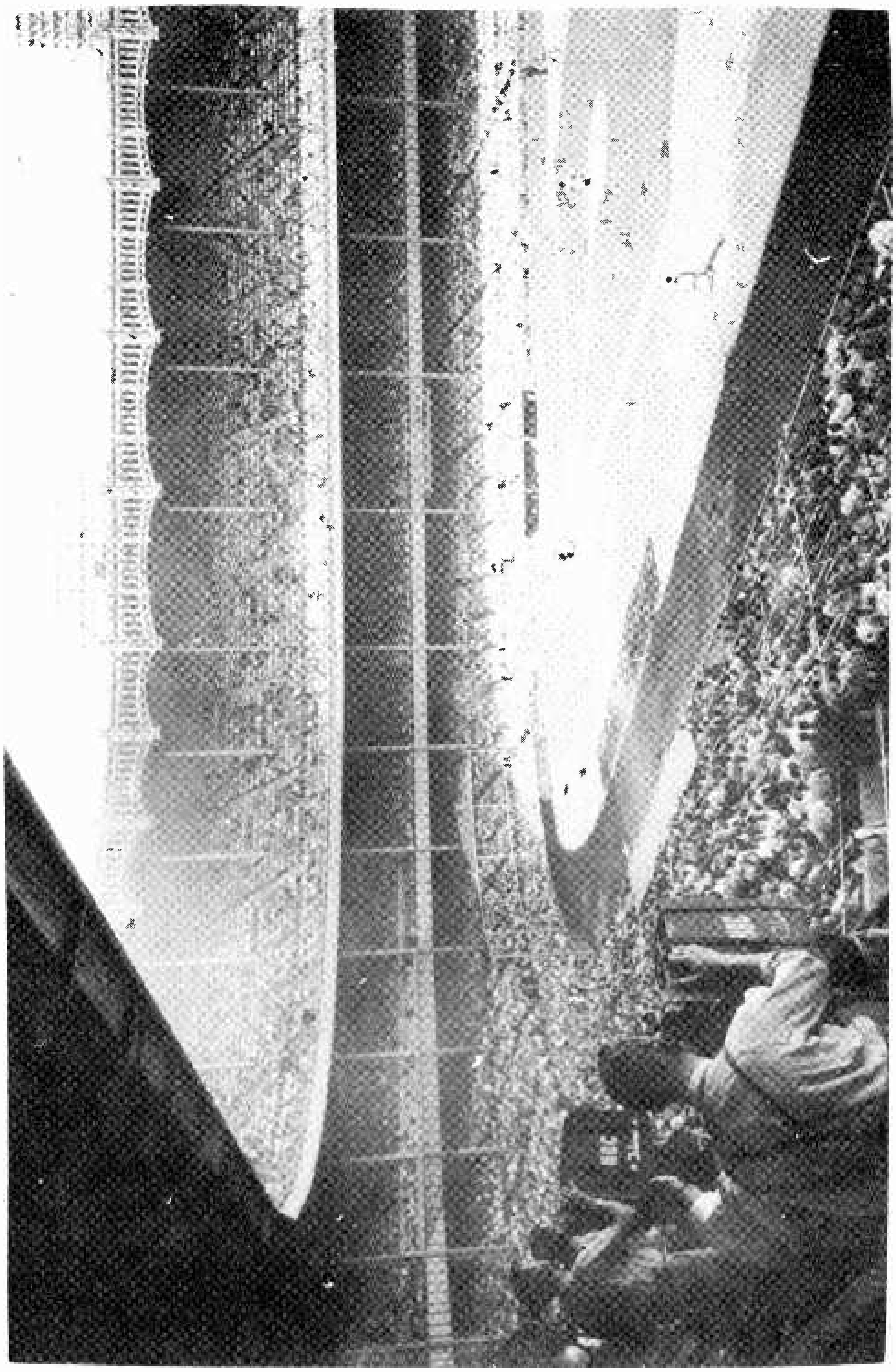


Fig. 11.--NBC's television station WNBT brings to viewers the Yankee-Boston Red Sox game at the Yankee Stadium. On left can be seen two new Image Orthicon cameras used to televise the game.

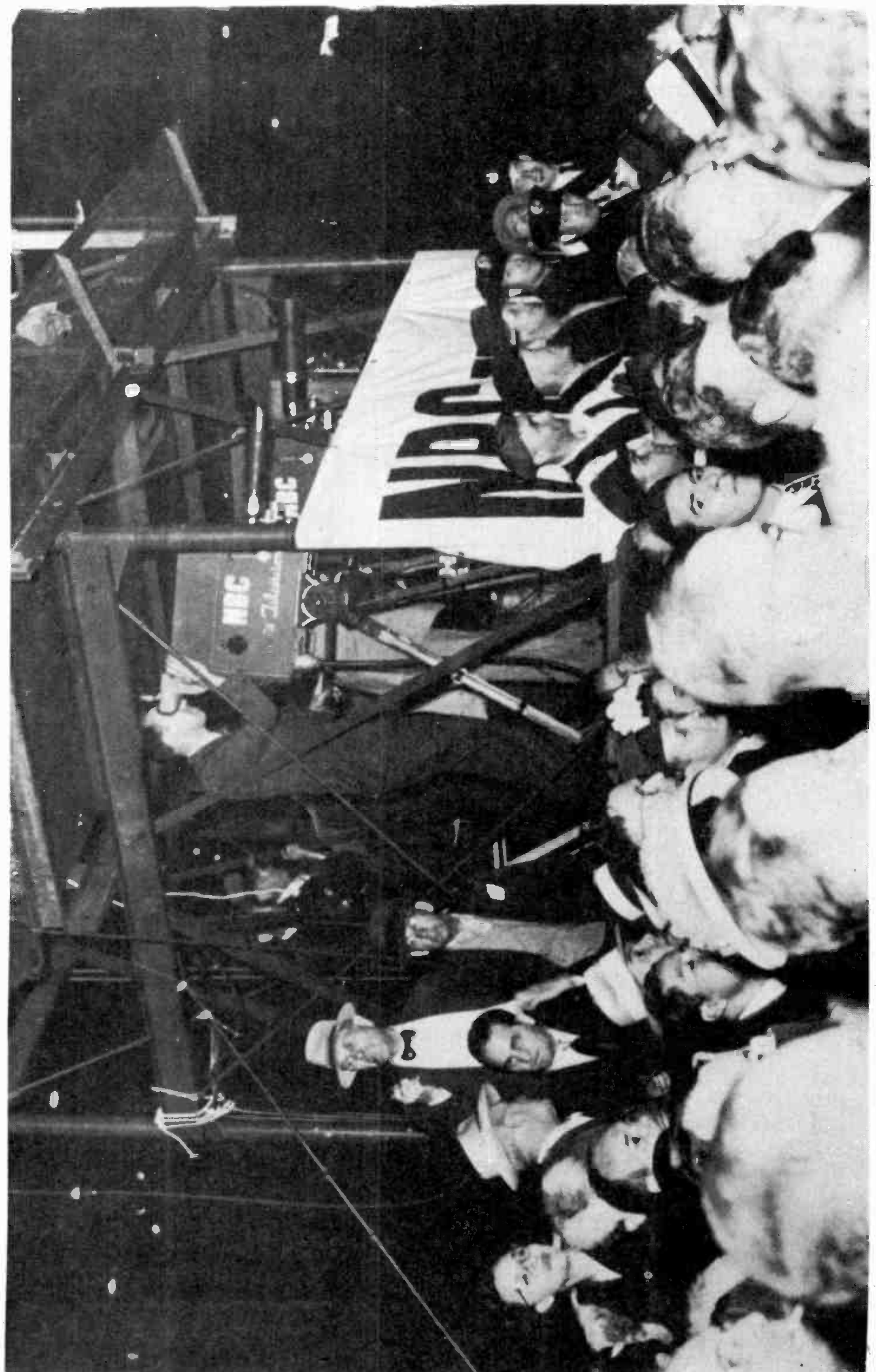


Fig. 12.--The new RCA Image Orthicon television camera in operation at Yankee Stadium, New York during the Louis-Conn fight.

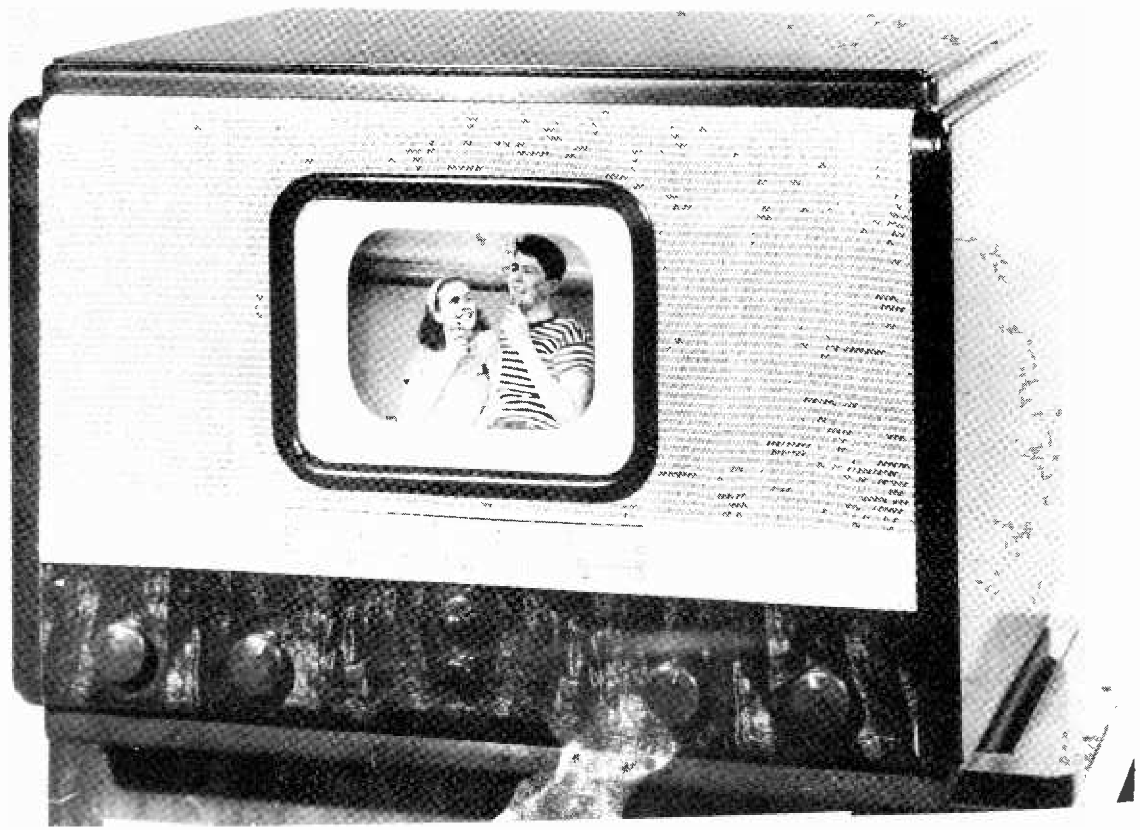


Fig. 13.--Belmont Television Receiver, showing modern cabinet design. Has new improved 7" picture tube. Employs two tuning bands which cover the entire spectrum of assigned television channels, making it possible to view all stations on the air. Picture brightness permits daytime viewing in average living room.

Fig. 14.--WRC-NBC guests viewing Louis-Conn fight via television—Statler Hotel, June 19, 1946.

jection-tube receivers. These employ a relatively small tube, on whose face is produced an intensely bright image. Potentials as high as 30,000 volts are required to produce this image. The latter is then focused by means of a special optical system on the rear of a translucent screen, which is in turn viewed from the front. The scene shown in Fig. 14 is that of the Louis-Conn fight, and indicates the large number of people that can view one receiver. A larger picture projection tube is employed for theatre projection, and normal-size screens can be covered with images of satisfactory brightness.

## CONCLUSIONS

This preliminary survey of television should drive at least one point home to the reader, and that is that television embraces and combines a large number of technical subjects. These range from psychology and physiology, with reference to seeing; optics, with reference to the imaging of scenes; electronics, with reference to amplification and pulse techniques; electrical engineering in general; the more recent developments of electron optics, which deal with the motions or trajectories of electrons in electric and magnetic fields; and sound and acoustics, which deal with the pickup and reproduction of sounds.

The result is that a well trained television engineer is a person of broad technical knowledge, who is able not only to handle television problems, but also other developments, such as radar, loran, etc. It will be found that this course inherently provides the student with sufficient background to handle problems in these allied fields in the process of training him specifically for television.

In view of the above, it will be clear that before television techniques can be discussed, a review of mathematics is desirable to refresh the radioman in the methods of computing the various formulas that arise in the practice of television. Such matters as the number of lines required in the scanning process, the calculation of current flow in an electrical circuit, the speed of a lens, the image distance for a given object distance and focal length of the lens, all require facility in the use of arithmetic, algebra, and some of the fundamentals of geometry and trigonometry.

It is therefore with no apology that the next assignment will be based on the fundamental and elementary processes of arithmetic, so that further problems in television can be more intelligently discussed. Following this will be an analysis of the mechanism of the eye, since television is inherently based on the action of this organ in conjunction with the brain.

# GLOSSARY OF TELEVISION TERMS

**ANTENNA FIELD GAIN:**

The term "antenna field gain" of a television antenna means the ratio of the effective free space field intensity produced at one mile in the horizontal plane expressed in millivolts per meter for 1 kilowatt antenna input power to 137.6 mv/m.

**ANTENNA HEIGHT ABOVE AVERAGE TERRAIN:**

The term "antenna height above average terrain" means the average of the antenna heights above the terrain from two to ten miles from the antenna. (In general a different antenna height will be determined by each direction from the antenna. The average of those various heights is considered as the antenna height above average terrain.

**ASPECT RATIO:**

The term "aspect ratio" means the numerical ratio of the frame width to frame height, as transmitted.

**AURAL TRANSMITTER:**

The term "aural transmitter" means the radio equipment for the transmission of the aural signal only.

**AVERAGE BRIGHTNESS**

The brightness of a source of light that furnishes the same amount of total light as the actual scene, and has the same frontal area as the actual scene. The average brightness corresponds to the d.c. component of the video wave.

**BLACK LEVEL:**

The term "black level" means the amplitude of the modulating signal corresponding to the scanning of a black area in the transmitted picture.

**BLOCKING OSCILLATOR**

An oscillator whose grid-time constant and feedback coupling are so high as to cause it to block or bias itself beyond cutoff after each positive alternation, whereupon it must wait until its grid-time constant permits to return within cutoff before it produces another oscillation.

**CENTER FREQUENCY:**

The term "center frequency" means:

1. The average frequency of the emitted wave when modulated by a sinusoidal signal.
2. The frequency of the emitted wave without modulation.

**CLAMPING CIRCUIT**

A circuit which holds one part of a wave, such as its negative peaks, to a certain datum value, such as zero, thereby forcing all other parts of the wave to lie above or below the datum value, instead of to either side of it.

CLIPPING

The process of cutting off, clipping, or limiting the amplitude of a wave, so as to delete all portions of this wave beyond a prescribed value. Means for producing this effect depend upon nonlinearity of the clipping device, which may be a diode or crystal, a vacuum tube operated beyond cutoff or beyond plate-current saturation. Also called limiting.

COLOR TRANSMISSION:

The term "color transmission" means the transmission of television signals which can be reproduced with different color values.

D. C. RESTORER

A type of clamping circuit in which the negative peaks—usually blanking pedestals—of the video signal are moved up to zero, thereby forcing all other parts of the wave to lie above zero. By this means a d.c. component is obtained from the initially pure a.c. input wave, whereby the average brightness of the scene may be represented.

DEFLECTION SURGE HIGH-VOLTAGE SUPPLY

A high-voltage low-current picture-tube power supply, produced by stepping up the deflection surge voltage, occurring during horizontal fly-back time, in a high-voltage secondary on the deflection output transformer, and then rectifying and filtering it.

DIFFERENTIATING

The process of obtaining an output wave whose shape represents—at least approximately—the derivative of the input wave (with respect to time). The circuit employed by a very low R-C or R-L network, or one employing mutual instead of self-inductance in conjunction with a resistance.

DIPOLE ANTENNA

This is, strictly speaking, a very short straight antenna, 0.1 wave or less in length, and in which the current is practically uniform along its length and of constant phase. Positive and negative charges appear at its ends, and vary in polarity at the excitation radio frequency. Also called doublet. The radiation characteristics of this antenna can be readily calculated, and any actual straight antenna can be regarded as made up of a succession of these dipoles; the radiation of the actual antenna being the same as the resultant of the radiation of all these dipoles. See also half-wave dipole.

DIRECTOR

A parasitic antenna element located in front of the main antenna element, and slightly shorter than it, used to increase the pickup in the forward direction as compared to that in the reverse direction. Often used in conjunction with a reflector element.

DISCRIMINATOR

A second detector or demodulator used in f.m. receiving circuits, for converting f.m. into a.m. and then recovering the modulation signal for subsequent amplification and actuating the output device, such as a loudspeaker.

DOUBLET ANTENNA

This is, theoretically, a straight-line antenna of infinitesimal length, at whose ends appear finite charges that vary in polarity at the excitation radio frequency. The radiation is at a maximum in a plane perpendicular to its length, and zero in the direction of its length. See also Dipole Antenna.

ECHOS

The displaced images appearing on the picture tube screen, produced by multi-path reflections. Also known as ghosts.

EFFECTIVE RADIATED POWER:

The term "effective radiated power" means the product of the antenna power (transmitter output power less transmission line loss) times (1) the antenna power gain, or (2) the antenna field gain squared.

EQUALIZING PULSES

These are pulses occurring at twice the horizontal scanning frequency, that precede and follow the vertical synchronizing pulse in groups of six. They aid in maintaining horizontal synchronization in spite of the non-integer relationship between the vertical and horizontal scanning frequencies.

FIELD FREQUENCY:

The term "field frequency" means the number of times per second the frame area is fractionally scanned in the interlaced scanning.

FLY-BACK TIME

The fraction of the scanning period devoted to the return of the beam from right to left, or bottom to top of the picture.

FOCUSING

The process of adjusting the electrode voltages of a cathode ray tube so as to cause the electron beam to form a minimum circle of light on the fluorescent screen. Also, in optics, the adjustment of the lens or mirror position relative to the object or the image screen to obtain a sharp optical image.

FOLDED DIPOLE

A half-wave dipole antenna, which is fed at the center, and whose ends are joined by a half-wave bar spaced a short distance from and parallel to the dipole.

**FRAME:**

The term "frame" means one complete picture.

**FRAME FREQUENCY:**

The term "frame frequency" means the number of times per second the picture area is completely scanned.

**FREE SPACE FIELD INTENSITY:**

The term "free space field intensity" means the field intensity that would exist at a point in the absence of waves reflected from the earth or other reflecting objects.

**FREQUENCY MODULATION:**

The term "frequency modulation" means a system of modulation where the instantaneous radio frequency varies in proportion to the instantaneous *amplitude* of the modulating signal (amplitude of modulating signal to be measured after preemphasis, if used) and the instantaneous radio frequency is independent of the *frequency* of the modulating signal.

**FREQUENCY SWING:**

The term "frequency swing" means the instantaneous departure of the frequency of the emitted wave from the center frequency resulting from modulation.

**GHOSTS**

The displaced images appearing on the picture tube screen, produced by multi-path reflections. Also known as echos.

**HALF-WAVE DIPOLE ANTENNA**

This is a straight-line antenna one-half wave in length, in which the current is everywhere in phase, but whose amplitude is a maximum at the center and a minimum at the ends. Its radiation characteristics are very similar to those of a doublet antenna.

**ICONOSCOPE**

An electronic camera pickup tube having a photoelectric mosaic on which the optical image is focused, and which is then scanned by an electron beam to furnish the output video signal. An important characteristic of this device is its ability to store the light information for any picture element during a frame time and then to release this information in the form of a relatively strong signal during the brief instant that element is being scanned.

**IMAGE DISSECTOR**

An electronic pickup tube in which an optical image is formed on a continuous photoelectric surface, the resulting electron image is deflected as a whole at the two scanning frequencies past a small aperture, into which successive portions of the picture enter, and are electron multiplied before being impressed upon an ordinary video amplifier.

IMAGE ORTHICON

An electronic pickup tube resembling the iconoscope, but being far more sensitive. It has a transparent photo cathode upon which the optical image is focused; the resulting electron image is multiplied or magnified upon a secondary emissive surface, which is scanned by an electron beam to furnish a video signal. This signal is then amplified by a multi-stage electron multiplier before being impressed upon an ordinary video amplifier.

INTEGRATING

The process of obtaining an output wave whose shape represents—at least approximately—the integral of the input wave (with respect to time). The same circuits are employed as for differentiating, but the output is taken from the opposite circuit element to that furnishing output in differentiation.

INTERLACED SCANNING:

The term "interlaced scanning" means a scanning process in which successively scanned lines are spaced an integral number of line widths, and in which the adjacent lines are scanned during successive cycles of the field frequency scanning.

ION TRAP

A magnetic arrangement, at the gun end of a cathode ray tube, which deflects an initially oblique electron beam into the axial direction of the tube, but which is unable to deflect the heavy negative ion clusters, so that these are captured by an off-set positive electrode.

KEYSTONE CORRECTION

A correction applied to the horizontal deflection wave in the form of modulation by the vertical deflection wave, in order to change a trapezoidal raster, produced by obliquity in the gun or optical system, into a rectangular raster.

LIMITER STAGE

An i.f. stage which saturates or limits when the signal exceeds a certain amplitude (threshhold value) and maintains a constant amplitude of output for all signal levels above the threshhold level. It therefore limits the output to a certain maximum value.

LIMITING

The process of cutting off, clipping, or limiting the amplitude of a wave, so as to delete all portions of this wave beyond a prescribed value. Means for producing this effect depend upon nonlinearity of the clipping device, which may be a diode or crystal, a vacuum tube operated beyond cutoff or beyond plate-current saturation.

AMPLITUDE MODULATION:

The term "amplitude modulation"(a.m.)means a system of modulation in which the envelope of the transmitted wave contains a component similar to the wave form of the signal to be transmitted.

MONOCHROME TRANSMISSION:

The term "monochrome transmission" means the transmission of television signals which can be reproduced in gradations of a single color only.

MULTI-PATH REFLECTIONS

Reflections of signals, radiated by the transmitting antenna, from obstacles not lying between the transmitting and receiving antennas. The signals thus reflected are directed toward the receiving antenna by the obstacles in a zig-zag or multiple path. The longer this path compared to the direct path, the later does the signal arrive, and the farther to the right is the image it produces compared to that of the direct-path signal.

PEAK POWER:

The term "peak power" means the power over a radio frequency cycle corresponding in amplitude to synchronizing peaks.

PEDESTAL

Also called blanking pedestal. A rectangular wave form injected during horizontal and vertical fly-back times to set the black level, extinguish the picture-tube beam, eliminate transient disturbances during this time, and act as a pedestal upon which the synchronizing impulses are superimposed.

PERCENTAGE MODULATION:

The term "percentage modulation" as applied to frequency modulation means the ratio of the actual frequency swing to the frequency swing defined as 100 percent modulation, expressed in percentage. For the aural transmitter of television broadcast stations, a frequency swing of ±25 kilocycles is defined as 100 percent modulation.

POLARIZATION:

The term "polarization" means the direction of the electric vector as radiated from the transmitting antenna.

PROGRESSIVE SCANNING:

The term "progressive scanning" means a scanning process in which scanning lines trace one dimension substantially parallel to a side of the frame and in which successively traced lines are adjacent.

PROJECTION TUBE

A small-screen cathode-ray picture tube, operating at very high gun potentials, and producing an intensely bright image, for projection through a magnifying optical system upon a large-size screen.

RATIO DETECTOR

An f.m. second detector which is inherently unresponsive to any amplitude modulation in the input wave, and responds solely to the frequency modulation.

REFLECTOR

A parasitic antenna element located behind the main antenna element and slightly longer than it, used to increase the pickup of signals in the forward direction, and to suppress signal pickup in the opposite direction.

R.F. POWER SUPPLY

A high-voltage low-current picture-tube power supply, produced by rectifying a high r.f. voltage generated by an oscillating vacuum tube.

SCANNING:

The term "scanning" means the process of analyzing successively, according to a predetermined method, the light values of picture elements constituting the total picture area.

SCANNING LINE:

The term "scanning line" means a single continuous narrow strip containing highlights, shadows, and half-tones which is determined by the process of scanning.

SCHMIDT OPTICAL SYSTEM

An optical magnifying system used to enlarge the small screen image of a projection tube to the large screen size desired for viewing. This optical system is characterized by a spherical mirror used for magnifying, in conjunction with a correcting lens to minimize spherical aberration.

SERVICE AREA:

The term "service area" as applied to television broadcasting means the service resulting from an assigned effective radiated power and antenna height above average terrain.

STANDARD TELEVISION SIGNAL:

The term "standard television signal" means a signal which conforms with the television transmission standards.

SWEEP GENERATOR

A test instrument for the servicing of receivers, that generates a signal whose frequency varies about a center frequency at a low-frequency rate, such as 60 c.p.s. The center frequency can be set to any value desired, such as in the r.f. range of the receiver, or at its intermediate frequency. The sweep range can also be adjusted to cover any band width desired within the scope of the instrument.

SYNCHRONIZATION:

The term "synchronization" means the maintaining of one operation in step with another.

SYNCHRONIZING PULSES

These are rectangular pulses superimposed on the pedestals and are employed to synchronize the deflection circuits in the receiver to those in the camera.

SYNCHRONIZING-SEPARATOR CIRCUITS

These are simple electronic circuits in the receiver that serve to separate the synchronizing pulses from the rest of the picture signal, as well as to separate the vertical from the horizontal synchronizing pulses.

NEGATIVE TRANSMISSION:

The term "negative transmission" means that a decrease in initial light intensity causes an increase in the transmitted power.

POSITIVE TRANSMISSION:

The term "positive transmission" means that an increase in initial light intensity causes an increase in the transmitted power.

TELEVISION BROADCAST BAND:

The term "television broadcast band" means those frequencies in the band extending from 44 to 216 megacycles which are assignable to television broadcast stations. These frequencies are 44 to 50 megacycles (Channel No. 1), 54 to 72 megacycles (Channels 2 through 4), 76 to 88 megacycles (Channels 5 and 6) and 174 to 216 megacycles (Channels 7 through 13).

TELEVISION BROADCAST STATION:

The term "television broadcast station" means a station in the television broadcast band transmitting simultaneous visual and aural signals intended to be received by the general public.

TELEVISION CHANNEL:

The term "television channel" means a band of frequencies 6 megacycles wide in the television broadcast band and designated either by number or by the extreme lower and upper frequencies.

TELEVISION TRANSMISSION STANDARDS:

The term "television transmission standards" means the standards which determine the characteristics of the television signal as radiated by a television broadcast station.

TELEVISION TRANSMITTER:

The term "television transmitter" means the radio transmitter or transmitters for the transmission of both visual and aural signals.

TRAP CIRCUITS

Rejection circuits, usually incorporated in the i.f. amplifier of a television receiver, to attenuate sharply and thus prevent the further transmission through the system, of the sound carrier or side bands of the same channel in the picture i.f. amplifier, or the sound or picture carrier and components of an adjacent channel.

VISUAL TRANSMITTER:

The term "visual transmitter" means the radio equipment for the transmission of the visual signal only.

VESTIGIAL SIDE BAND TRANSMISSION:

The term "vestigial side band transmission" means a system of transmission wherein one of the generated side bands is partially attenuated at the transmitter and radiated only in part.

VISUAL FREQUENCY:

The term "visual frequency" means the frequency of the signal resulting from television scanning.

VISUAL TRANSMITTER POWER:

The term "visual transmitter power" means the peak power output when transmitting a standard television signal.

V-9174-33

# *TELEVISION TECHNICAL ASSIGNMENT*

## *FUNDAMENTAL IDEAS*

### EXAMINATION

1. Explain some of the fundamental problems of commercializing television.

2. (A) Why cannot a television program be transmitted over an ordinary telephone line?

   (B) Explain two practical methods by which a television program may be transmitted over long distances.

3. Explain briefly the principles of facsimile transmission. How does this compare with television?

4. What is meant by "persistence of vision"? Explain. How does this apply in television?

5. (A) What is meant by synchronism as applied to television?

   (B) Why is a very high degree of synchronization essential?

6. (A) Explain the fundamental principles of scanning in television.

   (B) In television, what is the difference between true scanning synchronism and synchronous speed of scanning? Explain.

7. Explain fundamentally how a small moving dot of light is converted into an illuminated image at the receiver.

8. Why is television transmission limited to the ultra-high frequences? Explain.

9. What has the development of lenses and optical systems contributed to to the efficiency of television systems?

10. What width of frequency spectrum is required to transmit a television picture under present accepted standards? How is that channel proportioned?

V-9174-33.

1. Some of the fundamental problems of commercializing television are –

a. program pickup requiring development of cameras and proper lighting so a satisfactory picture can be obtained.

b. High cost of engineering and installing coaxial cable or ultra-high frequency relay links for network operations.

c. High cost of program material which requires long rehearsals and then can be used only once.

2. A. A television program cannot be transmitted over an ordinary telephone line due to its wide frequency band. Some of the frequencies would be distorted both in amplitude and phase.

B. One method of television transmission over long distances is by means of coaxial cable. This is a tubular conductor with a conductor through its center and insulated from it.

Another method is by use of ultra high frequency, or micro-wave, radio relay links spaced at intervals of line-of-sight across the country.

3. In facsimile transmission the picture to be transmitted is placed on a transparent cylinder. If a strong light beam is applied to the outside of the cylinder and a photo-electric tube placed inside the cylinder the current in the photo-electric cell will

vary in accordance with the light and the dark portions of the picture, as the cylinder is rotated on its axis and moved parallel to it. These variations in current are then amplified and transmitted by wire or radio to the receiving equipment. At the receiving end these varying currents are converted to a light beam of varying intensity which is applied to a photographic film mounted on a cylinder the same as is at the transmitting end. The cylinders have to rotate in synchronism. By this method a satisfactory 5"x8" picture is is transmitted in about four minutes, whereas a complete television picture is transmitted in 1/30 of a second.

4. Persistance of vision is the term applied to the fact that the response of the eye to the appearance of light and to its removal has an appreciable delay. If a light source is suddenly removed the eye still seems to see it for approximately 1/20 of a second. In television a moving spot of light is operated fast enough to form a complete picture in less time than this, so an apparent picture of continuous motion is produced.

5. A. Synchronism means that one operation is in step with another. In television it means that the scanning beam on the transmitting end is in step with the electron beam causing the spot of light in the receiver.

5 B. Without a high degree of synchonization the received picture will be distorted. If the length of time required to scan a complete line in the receiver is longer than in the transmitter the line will be shortened thus reducing the picture. If the synchronization is so poor as to get out of step "tearing" of the picture results.

6 A. In television scanning an electron beam moves horizontaly across the mosaic in the camera tube and across the face of the kinescope in the receiver in a series of lines equally spaced from top to bottom. The beam traces each line of the picture 30 times every second.

B. Synchronous speed of scanning means that the time required to trace a line in the receiver is the same as that in the transmitter. For true scanning synchronism it is also necessary that the identical line of the picture is scanned simultaneously at each end. & same relative position at all times.

7. The moving dot of light in the receiver scans each line of the picture 30 times every second. Due to the "persistence of vision" the sensation of light to the eye from the first time a line is scanned is still present when the scanning of that line is repeated. This applies to all lines so an apparently completely illuminated image is observed.

8. Television transmission is limited to the ultra-high frequencies because of the wide frequency band required. At lower frequencies the width of the side bands, as a percentage of the carrier frequency, would be so great that no interference free channels could be set up. Also at the ultra high frequencies the transmission range is limited to visual distances so a number of stations can be be operated on the same channel without interference if they are separated by about 200 miles.

9. One of the biggest problems in television is to obtain light of sufficient intensity for satisfactory operation of the camera and an electron beam of sufficient density. The development of lenses and optical systems has helped to overcome the above difficulties and thus contributed to the efficiency of television.

10. The width of a television channel is 6 mc. The video portion of this is restricted to 4.5 mc. There is an empty space between the video and sound frequencies and 0.25 mc between the sound carrier and the top of the channel.

5.75 Mc when using vestigial side bands