RCA

color television



ON DECEMBER 17, 1953, the Federal Communications Commission approved the standards for Compatible Color Television which had been presented to it by RCA, NBC and others. The RCA compatible color television system operates on the color standards approved by the FCC.



Color Television



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DAVID SARNOFF

TO CREATE television in color "as red as any rose" was a gigantic task. When we first began to think of television in the early Twenties we would have been content if only the rose could have been televised in black-and-white. That miracle had no sooner been achieved when the eye, sensitive to color, observed that the rose in monochrome lacked its true beauty, and the cry went up for color. Never had scientists been put under such pressure and demand.

Once American vision, ingenuity and industry were applied to the task, tints began to appear on television screens in the laboratories. To televise an apple and have it appear as an apple was problem enough. But to televise a pretty girl—the true color of her hair, eyes, lips and facial features—added to

the complexity of the task. And then to capture in motion a toss of the head, a wink, a smile, and add the sound of the voice — seemed like asking for the impossible.

But the word "impossible" is not to be found in the vocabulary of the scientist. Color television is a reality and will be recorded in the history of the Twentieth Century as one of the greatest, if not the greatest, of man's triumphs in linking science with the arts in the full glory of Nature. Flowers and flags, birds and beauties now are televised in color. Sunrises and sunsets, the rainbow, and even the sky which Ruskin described as "not blue color merely, but blue fire that could not be painted," now are televised in color.

Color follows light to which radio and television are akin. The electronic camera scans a simple garden scene, an array of flowers or an oak in its copper-hued autumn garb. In the twinkling of an eye the television transmitter transforms the picture into invisible waves that are broadcast to all points of the compass. Antennas atop millions of homes pluck the pictorial waves from space and guide them in the form of electricity to the television receiving set. At the flick of a switch or the turn of a dial, the scene reappears on the screen exactly as the camera "eye" saw it many miles away. To perform this split-second magic with true fidelity to colors and make realistic by every sound in the original scene — even the rustle of the wind or the buzz of a bee — is the miracle of color television.

Once all this could be done in color, it was comparatively easy to colorcast such spectacles as Niagara, the skyline of New York and the panorama of the Golden Gate. Baseball and football, prize fights and parades, drama and opera all fit into the pattern of progress.

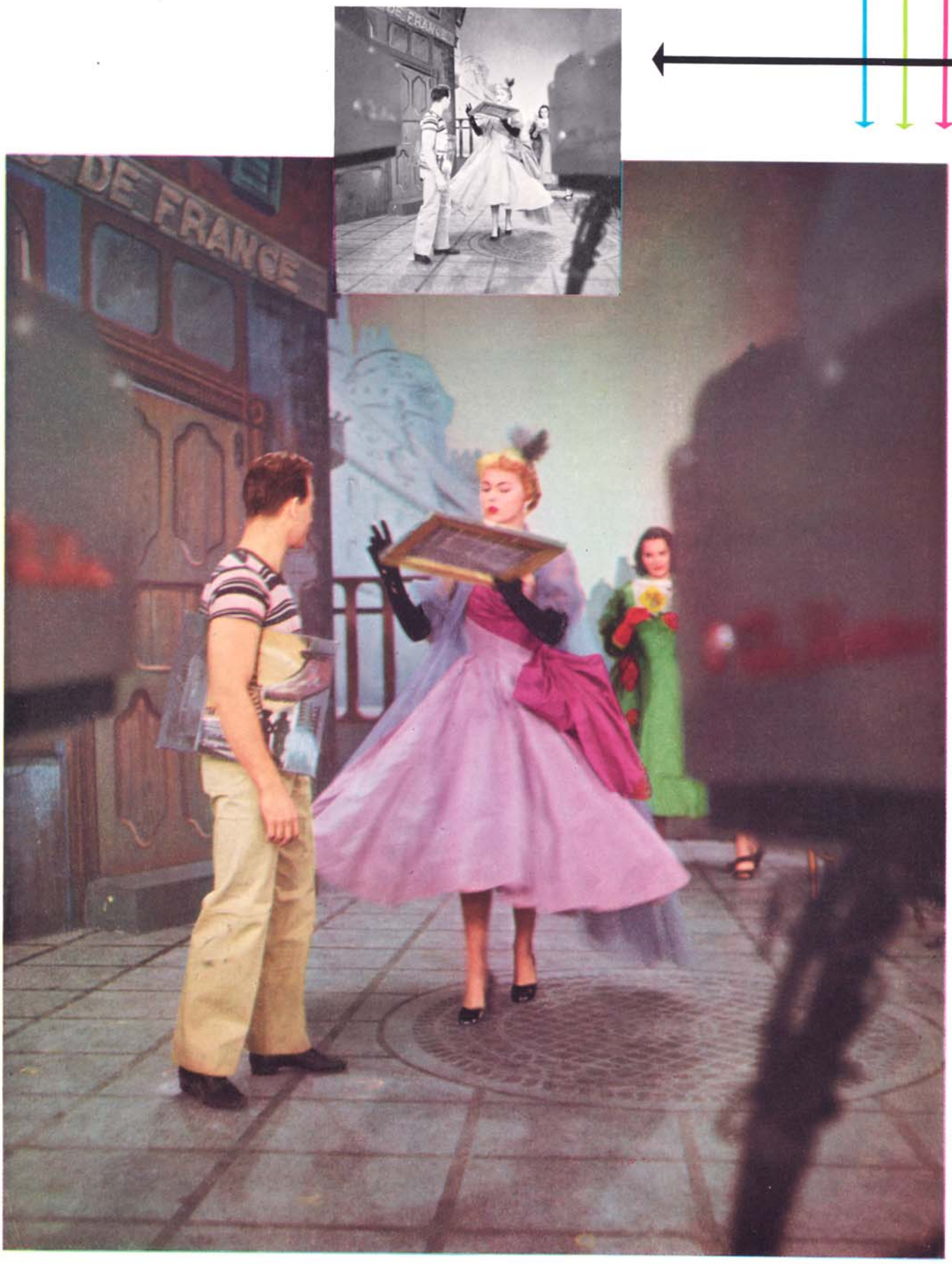
It has been my privilege, and a fascinating experience, to watch the scientists at work in color. I marvel at their accomplishment in bringing into focus the principles of radio, optics, electronics, photography, chemistry and many other essentials so that they might all work together to make color television practical.

For many years I have watched the research men and scientists pioneer and develop this new science and art in RCA Laboratories. I congratulate them, and our engineers, who created the compatible, all-electronic color television system and the famed tri-color tube. They have added a new dimension to the entertainment arts. They have given a new power to advertising and to merchandising. They have added realism to journalism and have intensified television as a social and educational force, opening the way for significant advances in television service to the public.

Color television has marshalled a great corps of experts from practically all fields of science. Many of them already had achieved fame and world-wide recognition in developing the RCA black-and-white television system. As I watch the results of their genius on the color screen, I often wonder if they, too, sit back and view with amazement and pride their successful emulation of Nature.

David Sarnoff

Chairman of the Board
Radio Corporation of America



Color brings reality to television, providing a new dimension of enjoyment

A World of Color

The beauty which old Greece and Rome
Sung, painted, wrought, lies close at home.
John Greenleaf Whittier

This is a world of color. From fingertips to doorsteps, from city streets to Nature's wonderland, across oceans and continents, *color captivates attention and brings the beauty of creation close to home.*

From sunrise until the last fading glow of sunset, by candlelight and firelight, neon, electric light and arclight, color exerts a powerful influence on people everywhere. Around the clock, it catches the eye in a myriad of ways, helping to identify objects, adding interest and stimulating pleasure.

Color transforms the commonplace into the beautiful; it makes the humdrum memorable.

In daily living, color is the great motivator of choice. It is the prime factor in selecting homes, clothing, automobiles, and ofttimes food and drink. More and more persons of discernment recognize that *color is the seasoning of what they see;* without it the world to them would be both tasteless and drab.

By the addition of color, *all of the visual arts attain increased value,* providing greater enjoyment and effectiveness in news presentations, entertainment and education. Magazine covers and illustrations come alive with tinted treatment; advertising beckons with "eye-appealing" hues.

Despite the important part that color plays in everyday life, only in recent times has there been a concerted effort to understand its characteristics and employ its properties scientifically.

Much of the confusion surrounding the subject of color has stemmed from the fact that the word itself has a great variety of definitions in popular usage. A scientific definition, in keeping with recommendations of the Optical Society of America, states the case in this way:

> *Color is a psychophysical property of light; specifically, it is the combination of those characteristics of light which produce sensations of hue, saturation and brightness in the normal human observer.*

Understanding Color

This may sound a little too difficult for the average person to comprehend. But, when the terms are simply described, understanding comes easily.

The term *hue* refers to the attribute of colors that permits them to be separated into groups designated as red, green, blue, yellow, purple, and so on.

The term *saturation* refers to "vividness" of a color or to the degree by which it departs from a neutral or gray shade of the same brightness. Thus, saturation is described by such terms as pale, deep, pastel and vivid. A neutral or gray color has zero saturation.

The term *brightness* refers to the intensity of a color, or to its position on a scale ranging from black to maximum white.

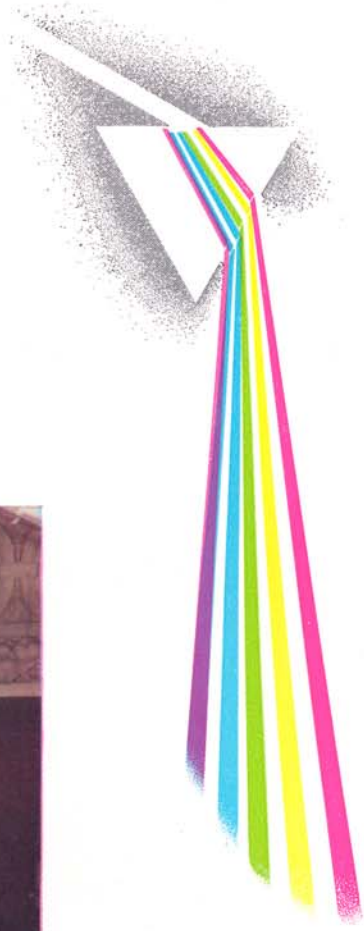
The term *psychophysical* in the definition indicates that color is not a property of light that can be evaluated by considering the physical attributes alone, such as wave length and power, but is a property that must be evaluated by considering the effect of light on the vision of human observers.

People speak of red apples, green automobiles, yellow lemons, and so on, as if the color were a property of the physical object, but actually the quality of the light source which illuminates the object is just as important as the object itself in determining the color reaching the observer's eye. For example, a "yellow" lemon might appear green when viewed under a light lacking in red radiation.

Since color is the property of light, it would be erroneous to describe it completely as a psychological sensation. While there is a very close relationship between color measurements and the color sensations of a normal observer under normal or "standard" conditions, there may be cases where such relationships do not exist. Some colors, for instance, are perceived under certain lighting conditions to be entirely different from the way they appear on color charts.

A scientific investigation of color generally falls into three distinct fields of study.

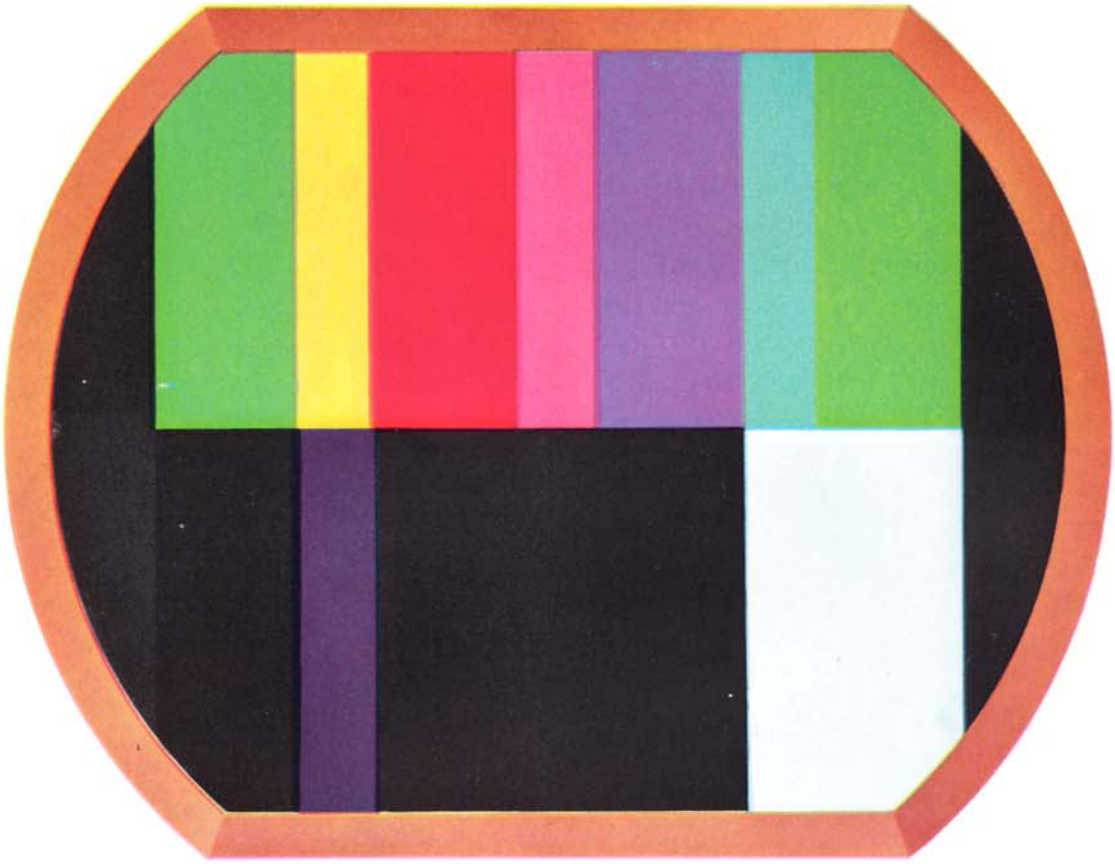
The study of light—the physical stimulus,



When white light passes through a prism, its color components are separated and appear as a rainbow



Color wheel for simulating fast motion for testing in studios



This pattern of electronically produced color bars is destined to become a familiar sight on monitors to indicate achievement of "right" tints

which produces color sensations—is in the realm of physics.

The study of the sensation itself, of the effect of the stimulus on the observer and the interpretations by the brain, leads to the fields of psychology and physiology.

A third field of study called psychophysics supplies a link between the physical aspects of color and the psychological aspects. It involves the evaluation of light in terms of the effect upon human observers.

Through this scientific approach, substantial progress has been made in techniques for reproducing color and applying color for human needs and desires.

Scientific understanding of color, although still far from complete, has grown rapidly in the last century. Teamed with mechanical, optical and chemical advances, it has led in recent decades to methods such as those used in high-speed color printing, color photography, and color motion pictures.

Meanwhile, modern electronics was coming of age. In the 1930's, television was being developed to a point of public acceptance. Pioneers of television were concentrating on black-and-white transmission and reception. *But a few believed that some day color images could also be transmitted and received electronically to provide instant and virtually unlimited distribution of scenes and action with the realism of everyday life, which is possible only with true color reproduction.*

Creating Color Television

To hold, as 'twere,
The mirror up to Nature.
Shakespeare



Color television—the newest feature in home entertainment

Creation and development of color television —inspired by the vision and leadership of Brig. General David Sarnoff, Chairman of the Board of the Radio Corporation of America—demonstrates dramatically what faith in science and the arts can achieve for public benefit.

It is a story of achievement that could happen only under the American system of free enterprise with service to the people as the ultimate goal.

It could happen only through dedication to that goal by hundreds of determined and skillful scientists, engineers, artists and administrators—working together as an RCA team to meet and overcome successfully the formidable obstacles encountered along the way between inception and final achievement of the all-electronic compatible color television system.

The advent of black-and-white television—pioneered by RCA a quarter of a century ago—raised the challenge of color at the start.

Sarnoff Defines Color Television Goal

As early as April, 1923, General Sarnoff, in a report to the RCA Board of Directors, said:

> "I believe that television, which is the technical name for seeing as well as hearing by radio, will come to pass in due course. . . . It may be that every broadcast receiver for home use in the future will also be equipped with a television adjunct by which the instrument will make it possible for those at home to see as well as hear what is going on at the broadcast station."

By July, 1930, when the art of television itself was still little more than a fascinating experiment, General Sarnoff predicted its development "to that stage when color as well as shadow will be faithfully transmitted" to bring the world's greatest art treasures vividly to the home.

Here was recognition that reality could be achieved only through color—that the eye does not normally see the world in black-and-white.

Thus, in 1930, the challenge of color television was accepted by RCA, and the goal defined.

The initial problem was, of course, to determine how the successful transmission of acceptable color could best be attained. The scientists took on the assignment with the energy and ingenuity that has ever been identified with RCA leadership in radio and television development. During the next ten years, research and engineering by RCA and the National Broadcasting Company, a service of RCA, laid the ground work for the phenomenal post-war growth of black-and-white television, and many of these fundamental developments provided the basis for experiments in color television.

First RCA Color Demonstration in 1940

A long process of patient and skillful research followed. On February 6, 1940, the first all-electronic reception of color, crude, of course, by today's high standards, was demonstrated to the Federal Communications Commission by RCA in Camden, N. J. This was a specific setup of apparatus to show the feasibility of electronic color TV.

A year later, the engineers of NBC joined the RCA scientists to achieve the first successful color telecast with an experimental transmission from the Empire State Building. This pioneer broadcast employed mechanical means to obtain color both in the studio and in the receiver—an expedient which had to be tested in the exhaustive search for the most practical color system, but which was soon to be discarded by RCA as impractical and outmoded.

With the coming of war in 1941, the skills and talents of the RCA organization were turned to the service of the Armed Forces. But by the war's end in 1945, the technological advances achieved in wartime research gave fresh impetus to the scientists and engineers as they dedicated themselves once more to the development of prac-

tical color television for the American home.

While enthusiastic post-war acceptance of black-and-white television established television as a permanent and deeply significant addition to the pattern of American life, it underlined the major problems to be overcome before the new dimension of color could be added.

Meaning of Compatibility

Not only would the new color system have to be completely electronic, it would also have to be fully compatible with the black-and-white system already accepted in good faith by the American public. Compatibility meant that broadcasts in color could be received in black-and-white on the millions of television sets in American homes without any adjustments or additions to the receivers. It meant that color transmissions, carrying much more information than black-and-white transmissions, would have to be squeezed into the same channel widths allotted to monochrome broadcasts by the FCC. RCA, with established leadership in scientific research and engineering as well as in broadcasting, would not propose a system that failed to meet these standards.

Step by step, the RCA scientists and engineers met and overcame the obstacles. One milestone after another was passed:

On October 30, 1946, an all-electronic projection type color television receiver, showing pictures on a 15 by 20-inch screen, was demonstrated publicly for the first time at the David Sarnoff Research Center of RCA, Princeton, N. J.

On April 30, 1947, color television pictures were projected on an 8 by 10-foot screen in a demonstration of the RCA all-electronic system at The Franklin Institute in Philadelphia.



Testing the RCA color television system on-the-air in Washington, D.C., in 1949



Coverage of news and special events outside of the studio achieved by mobile studios employing relay apparatus



Outdoor scenes and action are scanned and transmitted by remote camera units for rebroadcast by color TV stations

On July 16, 1947, a new RCA all-electronic color television camera was demonstrated to members of the FCC at Princeton on both a large screen and a home receiver.

Through all of these phases, the system remained in the laboratory stage as the researchers approached the problem of keeping the color transmission within the channel width for black-and-white broadcasting.

Then, on August 25, 1949, the successive achievements of the scientists and engineers reached a triumphant climax. RCA announced a system of all-electronic high definition color television operating within the 6 megacycle channel employed for black-and-white telecasting and transmitting color programs capable of reception in black-and-white on all existing home television sets with no modifications whatever.

Nearly two decades of research and development in the laboratories and workshops of RCA and NBC had achieved fulfillment of General Sarnoff's prediction of 1930. Here were the basic elements of a high quality color television system, assembled through years of patient and intensive effort into a form that proved beyond all doubt the practicability of all-electronic color as a new broadcast service.

The RCA Tri-Color Tube

There remained the task of developing the basic system into the simple and attractive form demanded by a public accustomed to increasingly high standards of black-and-white television. The equipment that had been demonstrated involved a color receiver fitted with separate picture tubes to receive the three color signals—red, green and blue—and to merge them optically into a single picture. This was not regarded as satisfactory.

While RCA-NBC engineers prepared and conducted field tests of the basic system with broadcasts over station WNBW, Washington, D. C., and over coaxial cable as well as over microwave relay between Washington and New York, RCA scientists and technicians continued to grapple with the problem of simplifying the receiver. Once more, patience, skill and devotion to



Drs. Engstrom, H. B. Law, and V. K. Zworykin examine experimental color TV picture tubes developed by RCA scientists and engineers



Beauty and simplicity of operation are basic in RCA color TV sets destined for the public

the goal of practical color television for the public achieved success.

On March 29, 1950, the public was invited to witness in Washington the first demonstration of a truly great accomplishment of modern electronics—the RCA tri-color tube. The development of this picture tube provided the vital link required to tailor the RCA system into a form suited to the American home.

Master Key to Practical Color Television

Acclaiming the development as miraculous from the standpoint of science and artistry, General Sarnoff said:

> "Measured in comparison with every major development in radio and television over the past fifty years, this color tube will take its place in the annals of television as a revolutionary and epoch-making device. When historians at the close of the Twentieth Century evaluate the most important scientific developments, I will predict that this tube will be among the great inventions of the second half of this century. As the master key to practical color television, it is an outstanding development of our time."

The tri-color tube represented the culmination of applied research by a group of dedicated individuals over a period of years in the fields of both black-and-white and color television. Combining for the first time all of the functions of electronic color reproduction in a single package, the new tube consigned to oblivion the mechanical scanning disk as a device for color reception in the home.

The RCA tri-color tube demonstrated great promise at the outset. Those in attendance at the historic demonstration in March 1950, saw for the first time a color receiver no different in outward appearance from the millions of black-and-white receivers already in American homes. At the same time, thousands of families in the Washington area viewed the color transmission in black-and-white on their home television receivers in a dramatic demonstration of the RCA system's compatability.

Elements of the new picture tube were built into a tube envelope, nearly identical in appearance to the standard monochrome picture tube. Two types of color tubes were shown by RCA at the epoch-making display—a single-gun version and the three-gun tube which has since entered production.

In May, 1950, General Sarnoff urged the Federal Communications Commission to approve color television standards based on the RCA all-electronic compatible system rather than upon a mechanical, incompatible system which would impose heavy costs upon the American public for the adaptation of black-and-white receiving sets. He pointed out that the RCA system had proved in demonstrations its high definition of light and color and its complete compatibility with the millions of black-and-white receivers in public use.

RCA Shares Its System with the Industry

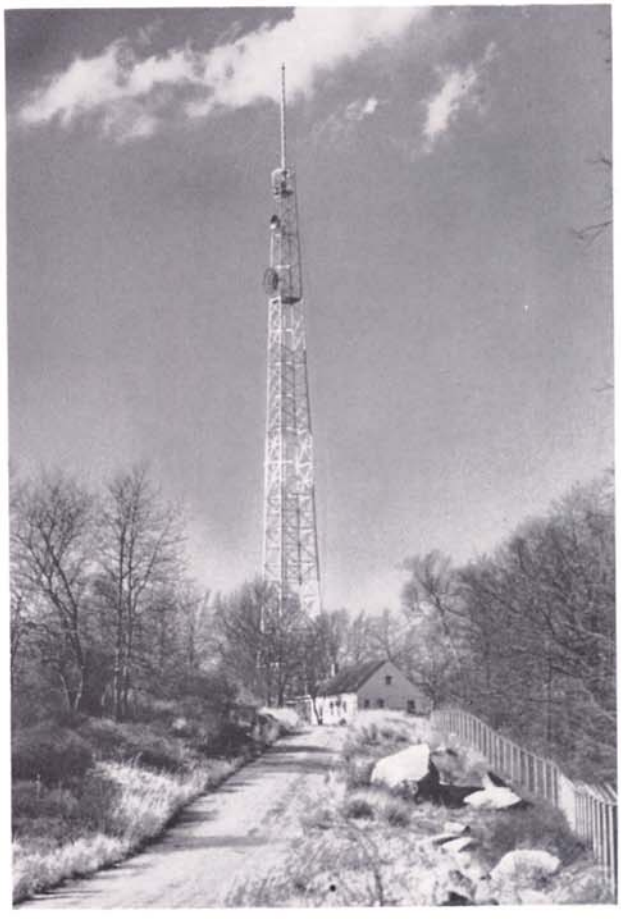
Although an FCC decision in 1950 approved incompatible color television standards, RCA moved ahead in the conviction that only the all-electronic compatible system could serve the public interest. Recognizing the task of introducing color television to the public as one for the entire industry rather than for a single manufacturer, RCA invited competing tube and set manufacturers to a demonstration in June, 1951, and made available to them without cost, samples of the RCA tri-color tube and kits of circuit components. This action, with but the single precedent established by RCA in black-and-white television four years earlier, ensured the ultimate introduction of color television on the widest possible basis.

Pioneering in UHF

The resources of RCA were devoted to field testing and refinement of the all-electronic compatible system. Recognizing that ultra-high frequency (UHF) facilities were destined to serve the television requirements of an increasing part of the national audience, RCA and NBC engineers conducted exhaustive tests with color transmission over their experimental UHF stations in Washington and Bridgeport, Conn., from 1949 to 1952. More than 600 hours were devoted to tests of color on UHF in Washington.

A total of 160 hours of color programs and technical tests were transmitted under varying conditions over the UHF installation at Bridgeport, including simultaneous broadcasting on both UHF and very-high frequency (VHF) channels. The tests proved beyond all doubt that the RCA compatible color system was as successful in UHF transmission as it was known already to be in the standard VHF range.

Hand-in-hand with the field tests went the labor of NBC artists and program directors in experimenting with the vivid new dimension of color. Experimental programs, featuring noted NBC artists, were transmitted with FCC permission to experimental color receivers as well as to conventional black-and-white sets in the homes of the viewing public.



Pioneer UHF station of RCA-NBC at Bridgeport, Conn., made broadcasting history, 1949 to '52



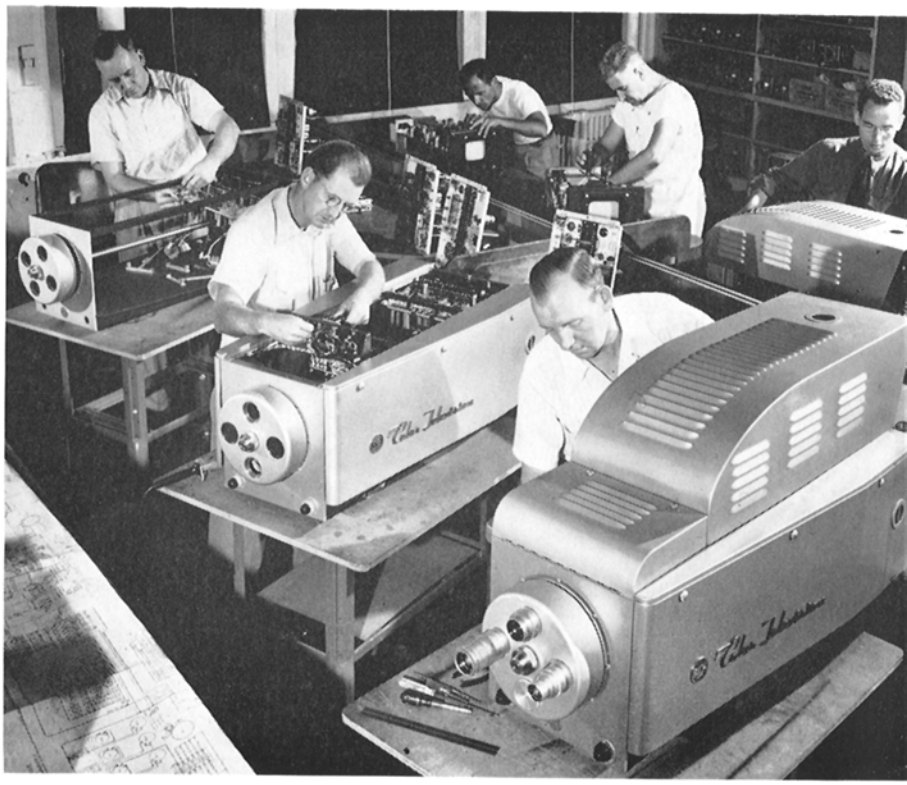
RCA shares its color television "know-how" and inventions with competitors of the radio-television industry



Hundreds of industry engineers have attended RCA clinics and seminars on tri-color tubes and color TV sets



Tri-color television picture tubes in pilot production at the RCA plant in Lancaster, Pa., receive testing



Color cameras being assembled at an RCA Victor plant for introduction of color TV service across the country

RCA Again Seeks Compatible Standards

In March, 1953, RCA again recommended immediate authorization of commercial color broadcasting standards by the FCC, and comprehensive demonstrations were staged during the Spring months for the FCC, to the Committee on Interstate and Foreign Commerce of the House of Representatives, and to the industry.

On June 25, 1953, RCA-NBC formally petitioned the FCC to adopt the compatible technical signal specifications used by the RCA system as standards for commercial color television broadcasting. Within two months, petitions for compatible signal specifications had also been filed by the National Television System Committee and by several other manufacturers.

These signal specifications are, in basic respects, similar to the standards which RCA proposed to the FCC at the 1949-1950 hearings, but naturally reflected improvements resulting from the knowledge gained during the research and field tests conducted by RCA and others since those hearings.

General Sarnoff stated that such standards are sufficiently high to leave ample room for future developments. On June 25, 1953, he said: "Like tracks of a railroad, these standards provide color television with a guage for a high quality right-of-way. Like railroad cars, color television receivers can be changed and improved in the future, and still operate on the same standards or tracks."

Twice in 1953, RCA invited industry representatives, including competing tube and set manufacturers, to share the "know-how" involved in the production and assembly technique of RCA color equipment. In July, RCA held a symposium for licensed tube manufacturers in order to make available the most up-to-date color tube information required to place a satisfactory design of color receiver into production. In October, engineers representing virtually all television set manufacturers were given design and performance details of RCA Victor's basic color television receiver, including tubes and circuitry as well as testing equipment. At the same time, all manufacturing licensees were promised the opportunity of inspecting RCA receiver production facilities before the first public release of commercial receiving sets.

On October 15, 1953, RCA-NBC joined with other members of the industry in a final demonstration held by the NTSC at the request of the FCC. This provided overwhelming evidence that all-electronic compatible color television, pioneered and developed by RCA, was ready for the American people.

A series of technical seminars to familiarize broadcast industry engineers with RCA's new color broadcast equipment were arranged for engineering consultants at the RCA Victor plant in Camden, beginning October 28 and 29, and followed by additional clinics for station engineers and executive personnel.

Servicing Color TV

Installing and servicing color television receivers present new problems to the industry. Recognizing this, the RCA Service Company has worked during the past four years with research and development engineers on color television. Thus, the Service Company technicians have familiarized themselves with the receiving end of this new art by testing, installing, demonstrating and maintaining RCA's developmental color television sets.

The RCA Service Company is preparing a special training course on the installation and servicing aspects of color television receivers for RCA licensees and service technicians. The course, covering the theory of color television and the practical down-to-earth problems in installation and maintenance of color sets, is to be conducted in New York, Chicago and Los Angeles. To aid in this training RCA technical specialists have prepared a comprehensive booklet "Practical Color Television for the Service Industry". In addition, RCA Institutes is making available a home study course on color TV servicing for industry personnel.

RCA Victor Production Plans

The key to the manufacturing operation was the pilot production line established in the RCA tube plant at Lancaster, Pa. Tri-color tubes for



Color TV camera boom moves into action at NBC's Colonial Theatre studio

test and demonstration purposes were produced on the line in 1952 and 1953 as the engineers studied and solved the initial production problems. At the same time, RCA production specialists made provisions for future expansion of tricolor tube production into existing black-and-white kinescope production facilities as the demand for the color tubes increased beyond the 2,000 per month output expected of the pilot plant.

Meanwhile, RCA Victor factory space was allocated for the production of home receiving sets, and the necessary test equipment was devised for ensuring the high quality of each RCA Victor color television receiver.

In addition, color broadcasting equipment, exhaustively tested in RCA-NBC field transmissions during the previous four years, was being built and made available to station operators. Due to the compatibility of the RCA system, it was necessary for stations to plan only relatively minor additions, estimated initially to cost about $22,000 in order to carry network color programs over their existing black-and-white transmitting facilities.

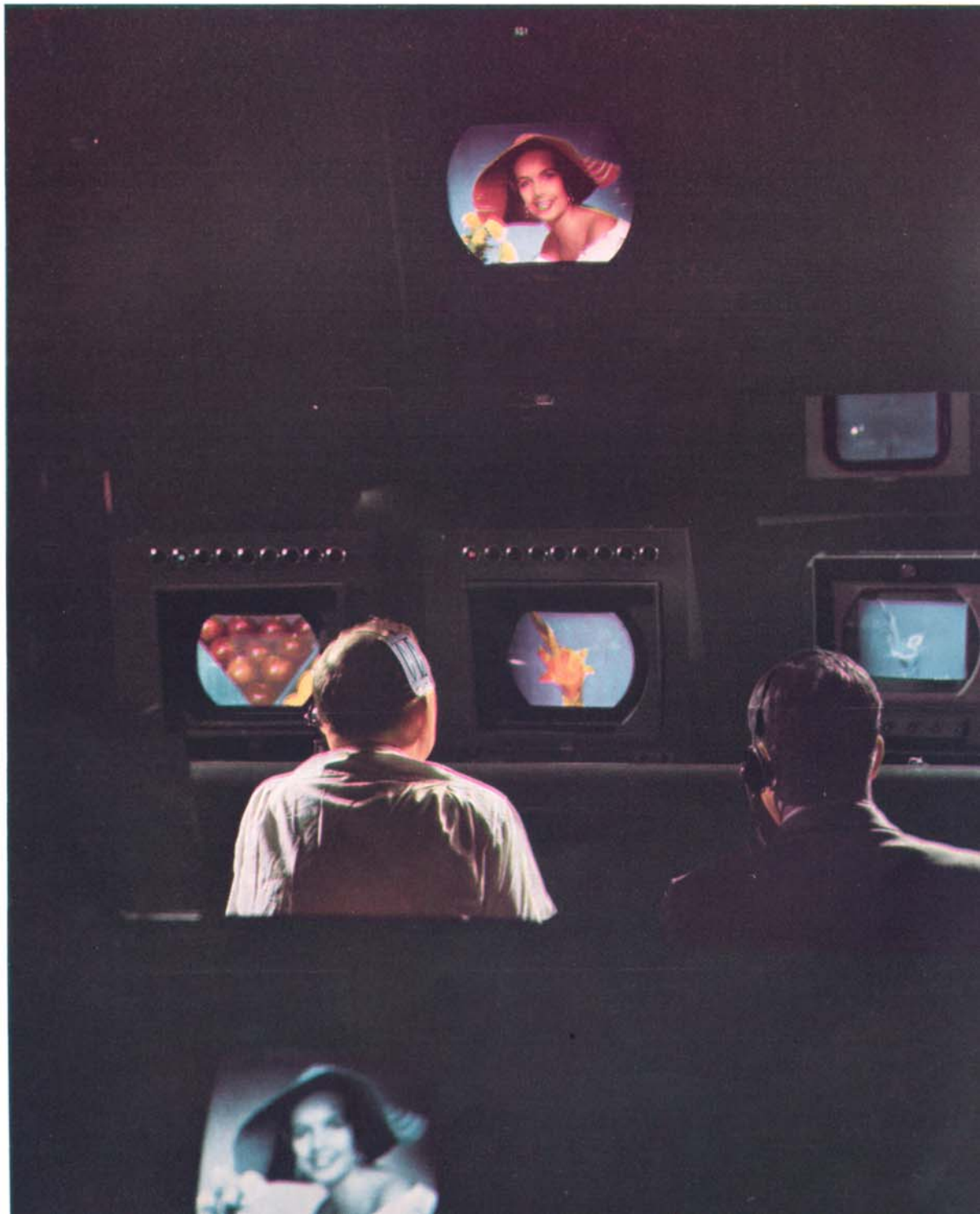
By December 1953, one or more stations in 57 cities had placed orders with RCA Victor for color broadcast equipment, consisting of color monitors and terminal apparatus to be added to existing TV transmitters, enabling stations to telecast network programs.

RCA color television cameras and other equipment necessary for origination of color television programs in the stations' own studios will be ready for delivery beginning in March, 1954. Included are cameras for "live" broadcasts, slide and film equipment, and accessories. All of this equipment has been fully tested during extensive experimental operations.

RCA had announced in July, 1953, that it was offering all stations an opportunity to place orders for color equipment. RCA plans to schedule deliveries of equipment for color broadcasting of network programs. This will enable stations to make full use of telephone circuits adapted to handle the transmission of color signals, when they become available. While plans have been based on orders already received, it is believed that deliveries on new orders can be made within a reasonable time after initial orders have been filled.

Broadcasting in Color

In the vaunted works of art,
The master-stroke is Nature's part.
Ralph Waldo Emerson



Pictures in color and black-and-white appear on monitors in control room of NBC Colonial Theatre studio in New York City



Preparation of color TV studio sets requires talent of expert decorators to achieve balance of tints



Nanette Fabray, favorite color TV star, has been on many pioneering telecasts conducted by NBC

Because of the firm foundation provided by RCA and NBC through painstaking development and orderly planning for the future, the introduction of color television as a revolutionary new service to the public is proceeding swiftly and effectively.

Immediately after the Federal Communications Commission approved compatible standards for commercial color television broadcasting, NBC inaugurated its master plan for an "introductory year" of color television programs.

Behind the efficient move of NBC programming into the exciting field of color were years of careful training, experimentation and preparation. For two years before the beginning of commercial color television operations, NBC had staged repeated experimental color broadcasts from two locations—Studio 3H in Radio City, and the Colonial Theatre in New York, the world's first and only television studios fully equipped for compatible color programming.

These test programs included transmission between New York and Chicago, and from New York across the nation to Hollywood. They provided the most practical kind of training in color television for NBC operating personnel, thus ensuring from the outset that the public would be served in the new medium by experienced directors, artists and technicians.

In addition, NBC established in mid-1953 a color producing group assigned to speed the conversion of the black-and-white television schedules to color. Producers and directors were instructed henceforth to plan all shows with an eye to their move into color.

Color Clinics Staged by NBC

Recognizing that the coming of color would have a profound effect upon television advertising techniques, NBC, during the summer of 1953, held a series of "commercial clinics" at which personnel of the advertising agencies were given the opportunity of familiarizing themselves with the techniques of color programming and broadcasting.

In these clinics, art directors and other creative personnel were sent by advertising agencies to the Colonial Theatre to work with NBC producing teams on the preparation of sample commercials on each agency's accounts. The test commercials were piped to the Center Theatre for viewing on RCA Victor color receivers by agency representatives. NBC initiative enabled advertisers and sponsors to plan well in advance for the versatility and depth added to commercial presentation through the coming of color.

In the network field, NBC encouraged a broad initial base for the advent of commercial color broadcasting. Experimental color programs had been sent over the NBC network during the months preceding the FCC decision and had been seen on black-and-white receivers in many sections of the country. When actual color broadcasting was started on a commercial basis, the majority of NBC network affiliates had signed contract amendments with NBC providing for their participation in network color broadcasting, and a number already had installed or ordered the extra equipment needed for monitoring the color signals.

Final preparations for the commercial broadcasting of compatible color television were marked by successful demonstrations conducted by NBC in the Fall of 1953. On September 22, a program was transmitted from New York to Chicago for the first viewing of compatible color TV in the Middle West during the Annual Meeting of the Association of National Advertisers. The first color telecast of a major opera was presented by NBC on October 21, in an hour-long performance of "Carmen" by the NBC Television Opera Theatre transmitted over the network.

On November 3, a live show performed in the NBC color television studio at the Colonial Theatre on Broadway in New York was relayed by microwave across the country to Burbank, California, and a color film also was televised for the first time from the Atlantic to the Pacific coast. Both of these demonstrations were coast-to-coast "firsts" in color television.

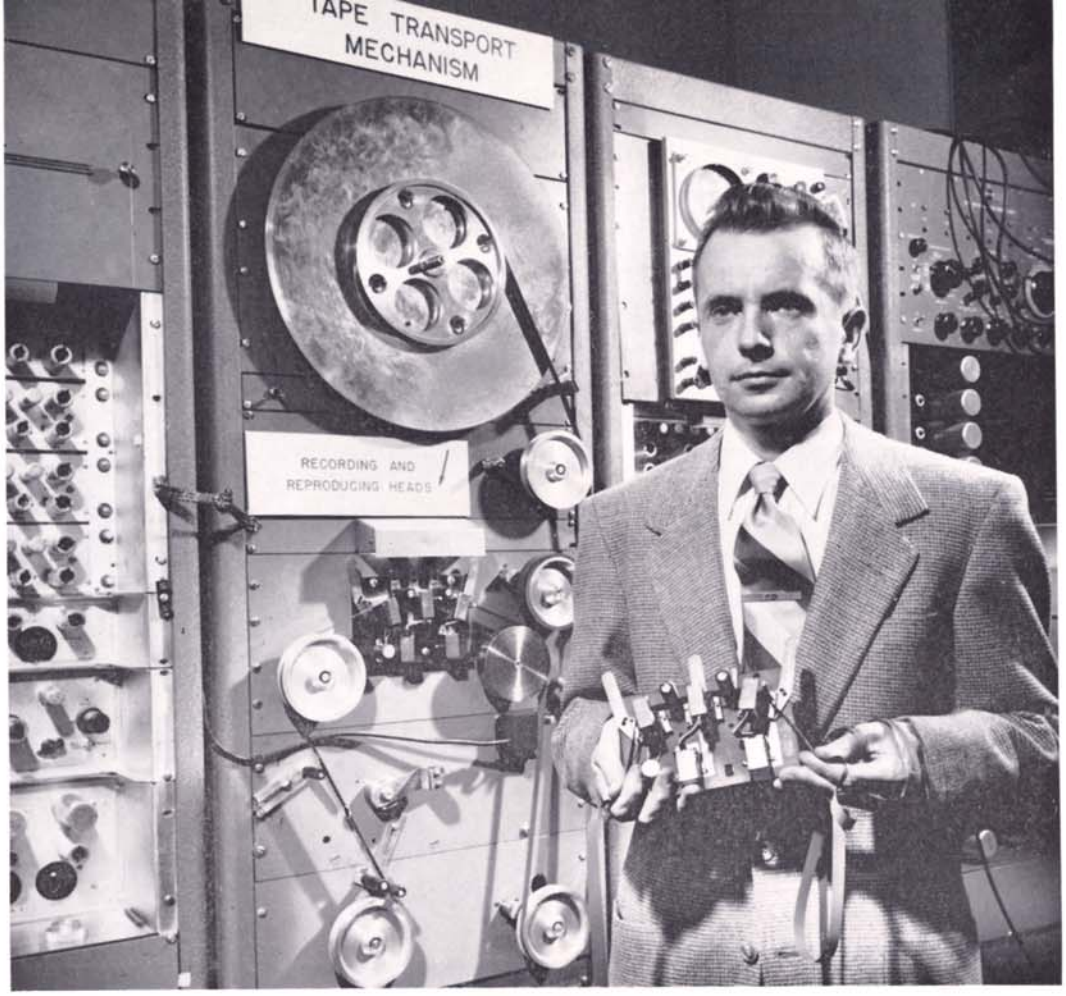
Thus, for the vast NBC audience, color television is being introduced as a practical service. Indeed, color television from the outset will be a highly developed operation capable of serving color receivers as rapidly as they are installed in homes throughout the nation. And, at the same time, the high standards of NBC service to black-and-white receivers will be fully maintained because they will be able to receive the color programs in black-and-white.

Great NBC Shows in Color

Under the NBC introductory plan, shows are broadcast as "color premieres" at the average rate of two a week from the Colonial studios. The advertiser has the opportunity of presenting his product in color with the show he sponsors. These color premieres are to include such television favorites as "Your Show Of Shows," "Kraft Theatre," "Milton Berle," "Colgate Comedy Hour," "Bob Hope," "Donald O'Connor," "Dave Garroway," and "Mr. Peepers," among others.



Colorful scene from NBC production of "Carmen" which thrilled viewers by its splendor and realism



This recording "head" shown by Joseph Zenel, research engineer, is a vital part of RCA's magnetic tape recording apparatus used to record television programs both in black-and-white and in color

With remote color TV gear, NBC proposes to include color pick-ups of outdoor events. Thus, a flower show, a fashion show, and such features as the blossoms of the Washington cherry trees can be seen in natural hues.

The Tournament of Roses at Pasadena, Calif., and the Mardi Gras at New Orleans are to be special event shows when circuits are available. Sports classics of football, baseball, and hockey eventually will be covered in color, as will dramatic tours of Niagara Falls, the Grand Canyon, the submarine gardens of Santa Catalina, and other beauty spots of renown.

Color television is destined to become the conversation piece of the country during this introductory year. The public, knowing that top performances are being broadcast in color, can be expected to intensify its interest in color.

Color's magnificent possibilities not only as a program stimulant, but as a revolutionary influence on advertising, sales and promotion, will have a dramatic impact in merchandising.

Magnetic Tape Recording of TV

A new and revolutionary advance—the recording of color as well as black-and-white television programs on magnetic tape was demonstrated by RCA on December 1, 1953 at the Princeton laboratories.

Commenting on this development, General Sarnoff said: "This new method of recording sight is similar in basic respects to tape recording of sound. The achievement is the first major step into an era of 'electronic photography,' in which motion pictures in color or black-and-white will be produced quickly and economically, without any photographic development or processing.

"Magnetic tape recording of television pro-

grams has great possibilities first for television broadcasting and, later, for national defense, for the motion picture and theatre industry, for industry in general, for education, and for home entertainment.

"While this electronic video tape equipment is still in the developmental stage, the basic principles and principal elements of our system have been tested and confirmed. We are confident that it is only a matter of time, perhaps two years, before the finishing touches will bring the system to commercial reality.

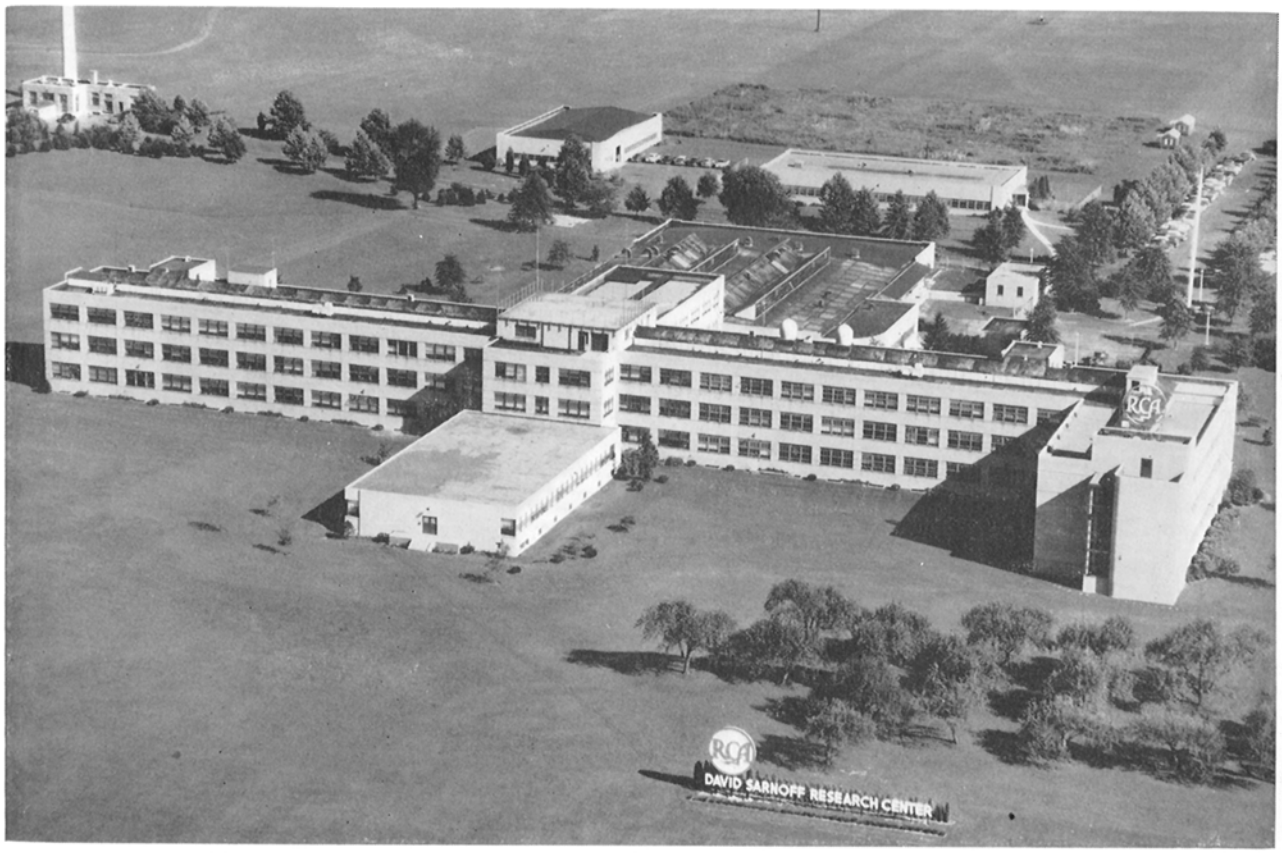
"It is essential for the future of the television art that video tape recording be introduced to give the television industry a practical, low-cost solution to program recording, immediate playback, and rapid distribution. Video tape will be important for black-and-white broadcasting; it will be essential in the creation of a full color television service.

"According to our present estimates, the cost of recording a color television program on magnetic tape would be only five percent of what it would cost to put it on color film, since the tape can be reused."

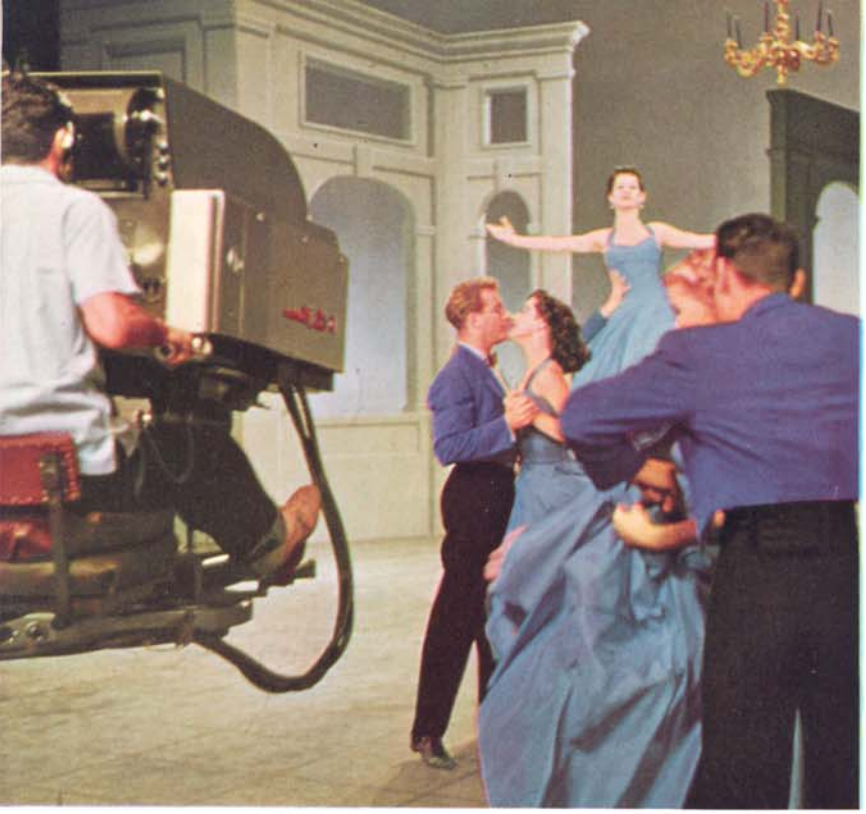
General Sarnoff, declaring the development had far wider horizons than its immediate purpose in TV broadcasting, pointed out advantages of magnetic tape over ordinary film.

"Magnetic tape requires no chemical processing," he said. "The pictures can be viewed the instant they are taken, which adds new flexibility in making motion pictures. An unlimited number of copies of magnetic tape recordings can be made quickly. Recorded tapes can be preserved indefinitely for historic reference, or, if desired, can be electronically 'wiped off' and reused again and again. With further development of video tape techniques, numerous possibilities will open up."

"Electronic motion pictures—in black-and-white and in color—for television, for the theatre, and for the home will stem from this remarkable development," continued General Sarnoff. "To-



David Sarnoff Research Center of RCA, at Princeton, N.J.



Blue tones and subdued backgrounds lend themselves well to romantic interlude in color TV

Dolores Gray (in dark dress), Broadway vocalist, and flower girl face camera during test broadcast



day we are only on the threshold. But the electronic door has been opened wide and gives us a fascinating vista of the future."

Future Horizons of Color Broadcasting

Thus, as the color television era opens, the resources which RCA has devoted through the years to basic preparation and introduction of the new art of color are focused on the means of ensuring its spread and future growth.

In the broadcasting studios of NBC, new program techniques are being sought and tested to exploit the full beauty and reality of the color medium for public enjoyment and enlightenment.

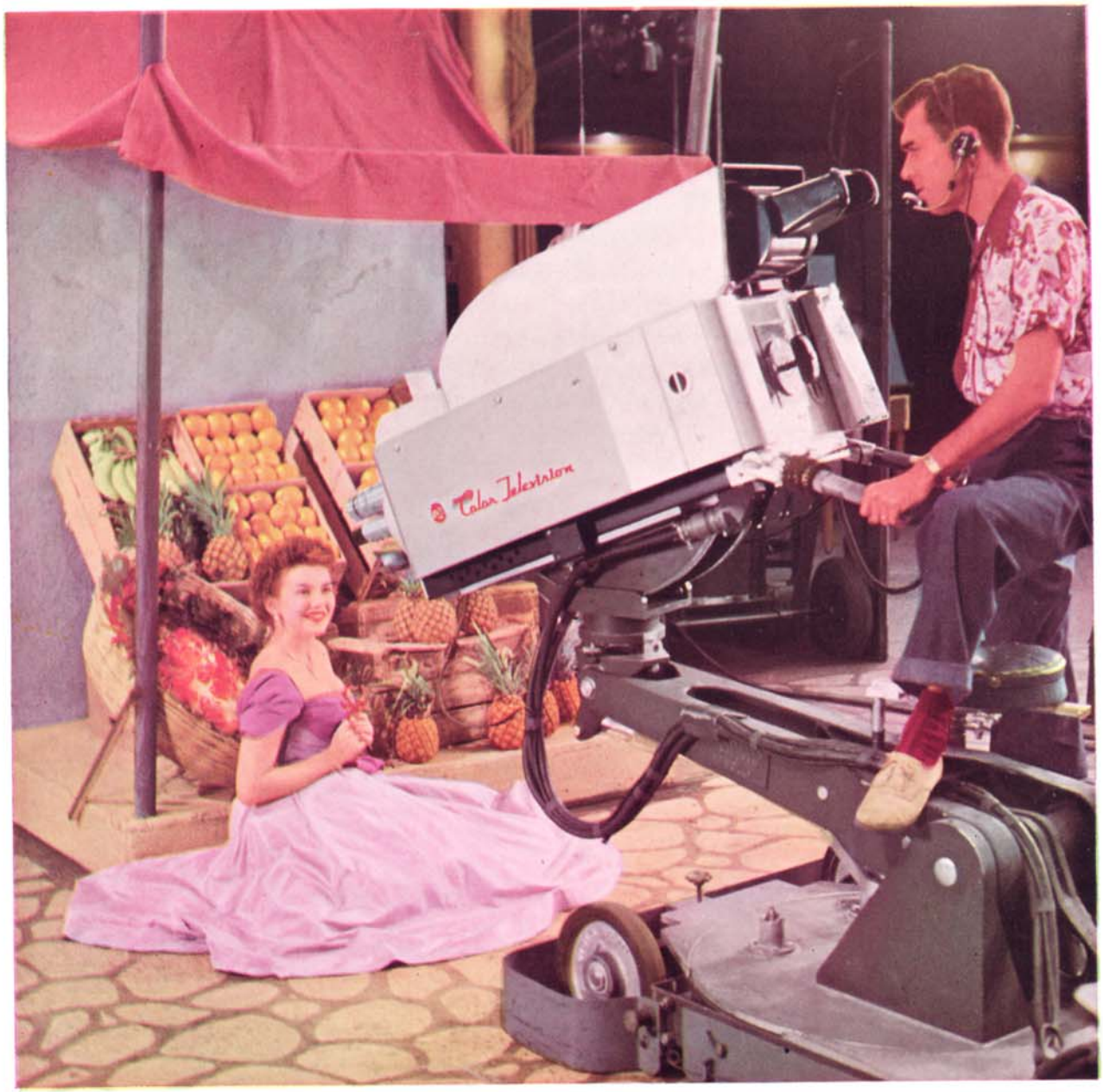
In the plants of RCA Victor, production techniques are undergoing study to insure the highest quality receivers at the lowest cost.

In the David Sarnoff Research Center of RCA, the scientists who have devoted years of painstaking effort to the discovery and development of the all-electronic compatible color system, continue with the same skill, energy and determination to seek the constant improvement that marks RCA leadership in color as in black-and-white television.

The creation of the RCA compatible color system has translated the earlier miracle of television itself into a vivid and revolutionary dimension of untold promise for the future of human understanding and enjoyment.

As General Sarnoff has declared: "In the creation of color television, science has endowed us with a priceless gift. *The glory and reality of nature, the inspired expression of master artists and musicians, the full drama and excitement of human affairs may now speed with the swiftness of light into the homes of men.* In the years that lie ahead there will be growth and adaptation in this art, and ultimately a system of color television that will extend across the oceans, bringing all peoples together in the common appreciation of their varied ways. *It may well be that we have brought to birth in all its essentials the ultimate in human communications—a deeply significant force which may ultimately dissipate the tensions among men and inspire mutual understanding and respect."*

How Color Television Works



Color television opens new era in communications and entertainment arts

Compatible, all-electronic color television, pioneered and developed by the Radio Corporation of America, is one of the outstanding scientific and artistic achievements of the 20th Century.

Many long years of hard work and financial risk are behind this great development.

RCA has spent more than $25,000,000 to achieve the objective of adding the beauty and reality of color to the black-and-white service of television. RCA and NBC will invest an additional $15,000,000 during color television's introductory year to establish this new service on a solid foundation. RCA spent $50,000,000 in developing and establishing black-and-white television and, as a result, the public, RCA and the entire industry have benefited.

To understand the magic of color TV, and the ingenuity behind it, familiarity with the principles of black-and-white television are needed at the start.

Black-and-white television, as developed by RCA, is an all-electronic system that picks up an original scene, transmits it through the air, and then recreates the original scene at receiving points. The programs are broadcast directly from television stations which, for network operation, are connected by microwave radio relay circuits or coaxial cables.

But a complete picture cannot be sent at one time. It must be broken up into exceedingly small units. Each unit is then transmitted as an electrical signal which represents the relative brightness of that unit. By arranging for the orderly transmission of these signal units, one following the other, it is then possible at the receiving end to reassemble the picture with each unit in its exact position and in its original shading, ranging from black to white. By transmitting a number of consecutive scenes rapidly, (30 per second in the case of television) the viewer is given a sense of motion in much the same way that the motion picture film gives the impression of life-like movement.

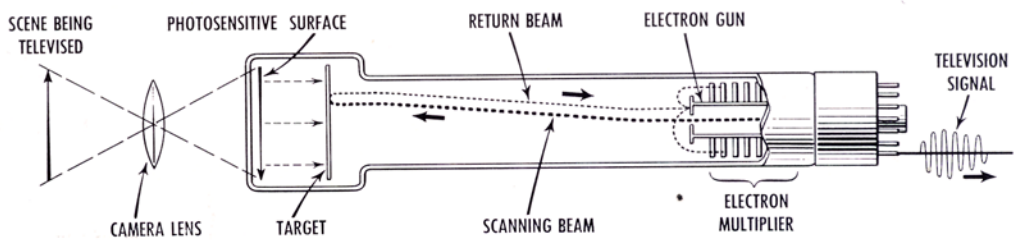
In television, as in photography, a camera is essential for picking up an image of a scene. The "heart" of a television camera is an electron tube which performs a function similar to the film in a photographic camera.

Image Formed of Electrons

The camera tube, developed by RCA scientists for this specific purpose, is the image orthicon. In appearance, it resembles a large size flashlight. At one end is a flat photo-sensitive glass surface on which a lens focuses a light image of the scene to be televised. The appearance of the visible image instantly creates on a target inside the tube an identical image formed of electrons. The number of electrons at each point of this invisible image corresponds to the intensity of the light at that point in the original scene.

The next step is to "read" this electron pattern so that each unit area in its composition can be evaluated and then transmitted to receivers. This is done by scanning this charged image by a beam of electrons shot from a "gun" at the opposite end of the image orthicon. This beam, pin-point small, scans the electron image from side to side and top to bottom just as the human eye scans a printed page, but a thousand times faster. When this beam reaches the image it loses different amounts of electrons depending on the charges it meets, and then returns to a

RCA IMAGE ORTHICON TUBE

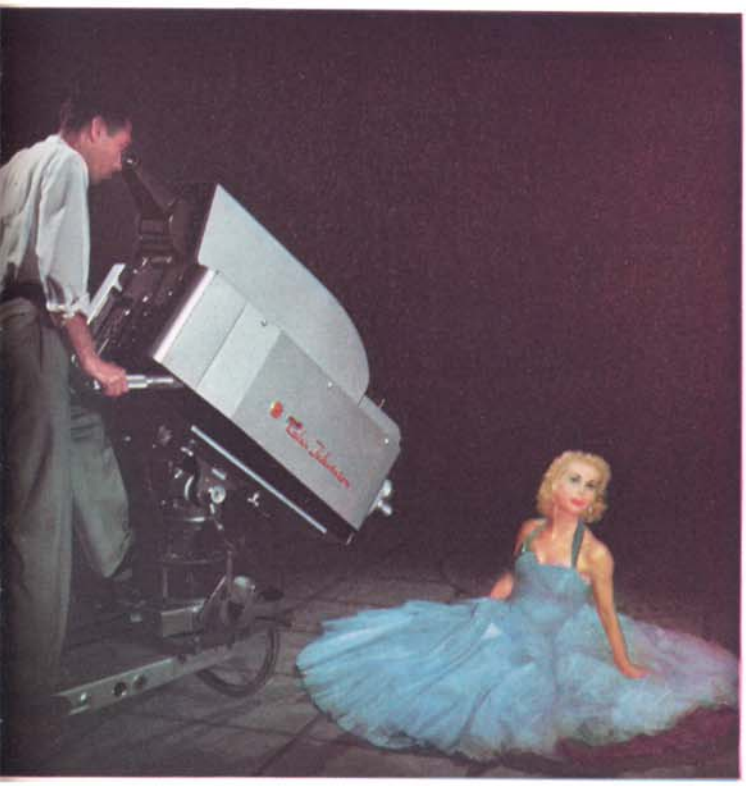


spot near the "gun," where the electrons are amplified millions of times and led off to the transmitter in the form of an electric current. This alternating current forms the heart of the television signal, which is radiated into space by the transmitting antenna.

At the receiving end of the television system, an antenna intercepts a bit of the electromagnetic energy which has been sent from the transmitter. This energy causes a current to flow which is fed to the receiver. After the signal is amplified and processed by an array of tubes and components in the receiver, it is impressed on a picture tube, called the kinescope, also an RCA development. An electron beam in the kinescope "paints" the received picture on the face of the kinescope. The screen of the picture tube is coated with fluorescent material, a phosphor, which glows at any point when stimulated by the electron beam.

In today's black-and-white television, the image of the scene is, in effect, divided into 525 horizontal strips, a small fraction of an inch in width. The scanning beam at both camera and receiver completes the scan of each picture thirty times a second. As the beam moves along its directed path in the tube, its energy varies constantly to conform to the differences in illumination of the original scene. As a consequence, the impact of the beam on the fluorescent surface of the picture tube rapidly constructs a pattern made up of tens of thousands of these dots of light which, in each 1/30th of a second, reproduce for the eye an entire scene in black and white.

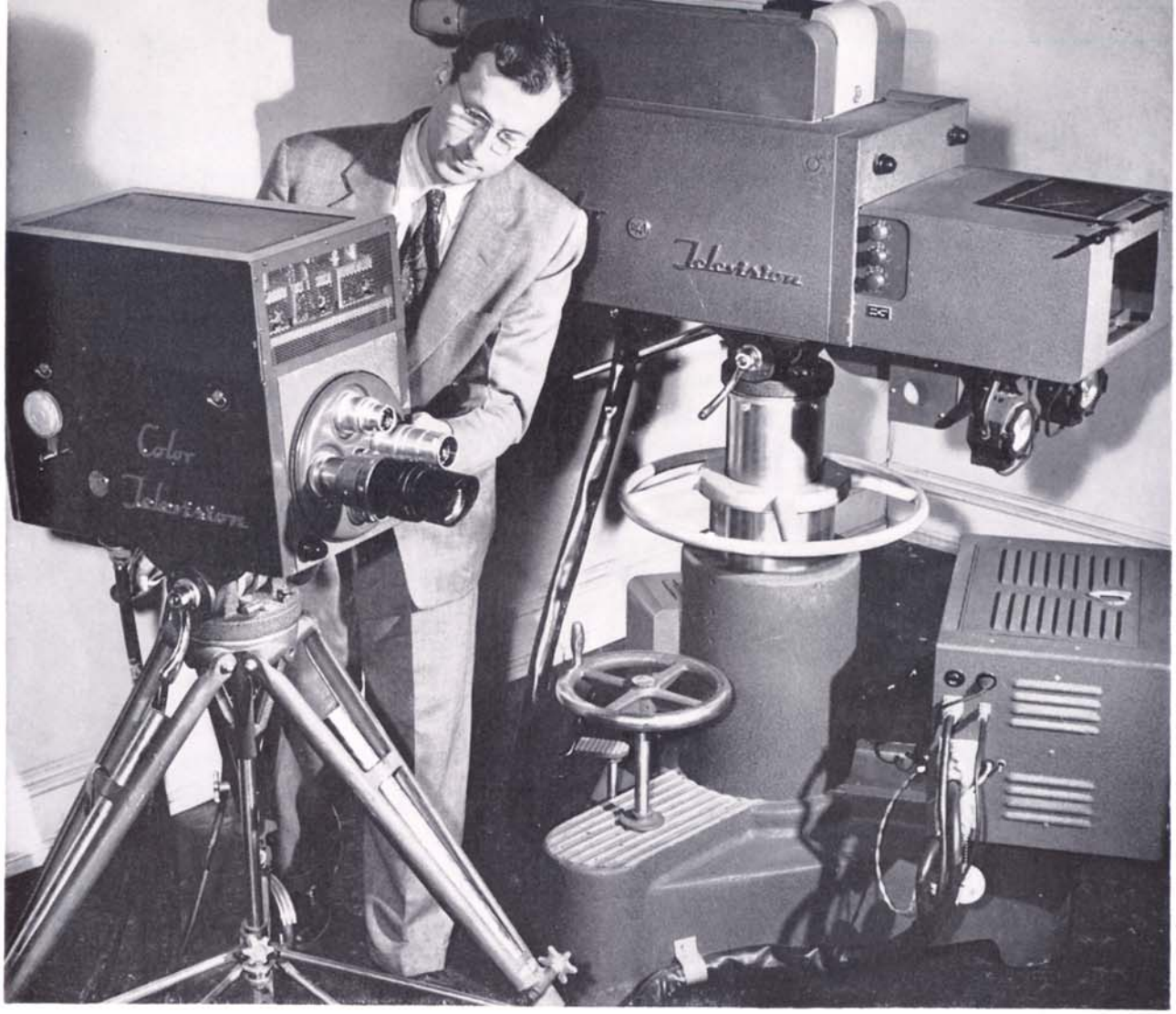
By electronic means, the scanning beams at transmitter and receiver are locked together, synchronized, throughout the telecast so that under normal conditions the resulting picture is a good reproduction of the original scene, free from distortion and unnatural movement.



Color television cameras are able to move in quietly for closeup "takes" of studio scenes for the added enjoyment of viewers



Beauteous details of face and form emerge on screen of home color television sets



Under development by RCA engineers is this color camera which uses only one pickup tube

The scanning rates and other operating specifications of black-and-white television have been standardized by the Federal Communications Commission, hence the signal from any television station can be received by any television receiver within range.

To prevent the stations from interfering with each other, the FCC has allotted channels or "highways" in the radio spectrum for the transmission of television programs as it has for other types of radio transmission. The television channel, because of the mass of information (the number of details per picture per second) it must carry, is 6,000,000 cycles (6 megacycles) in width as compared to 10,000 cycles for AM radio broadcasts and 200,000 cycles for FM programs.

Color Is Added

When color is added to black-and-white images, as in the system developed by RCA engineers, more information must be carried by the TV signal without exceeding the standard 6-megacycle bandwidth occupied by standard TV stations. How this is accomplished is one of electronics' most notable triumphs and will be discussed later. But first, a brief description of color and its relation to human vision.

Hue, saturation and brightness are the three terms that define any color scientifically and indicate a color's probable effect on the human eye and brain:

Since the basic black-and-white picture signals fill a standard TV band, how, it might be asked, can an already crowded band handle the additional signals which are necessary for the carrying of information about the hue and saturation of the image. To perform this feat, RCA engineers have developed a method which places the additional signals upon the monochrome or brightness signal in such a manner that they can be readily processed at the receiver and applied to the tri-color kinescope. This operation is sketched in the step-by-step picture diagram on page 28. The diagram also indicates how a compatible color signal is reproduced as a high quality black-and-white picture.

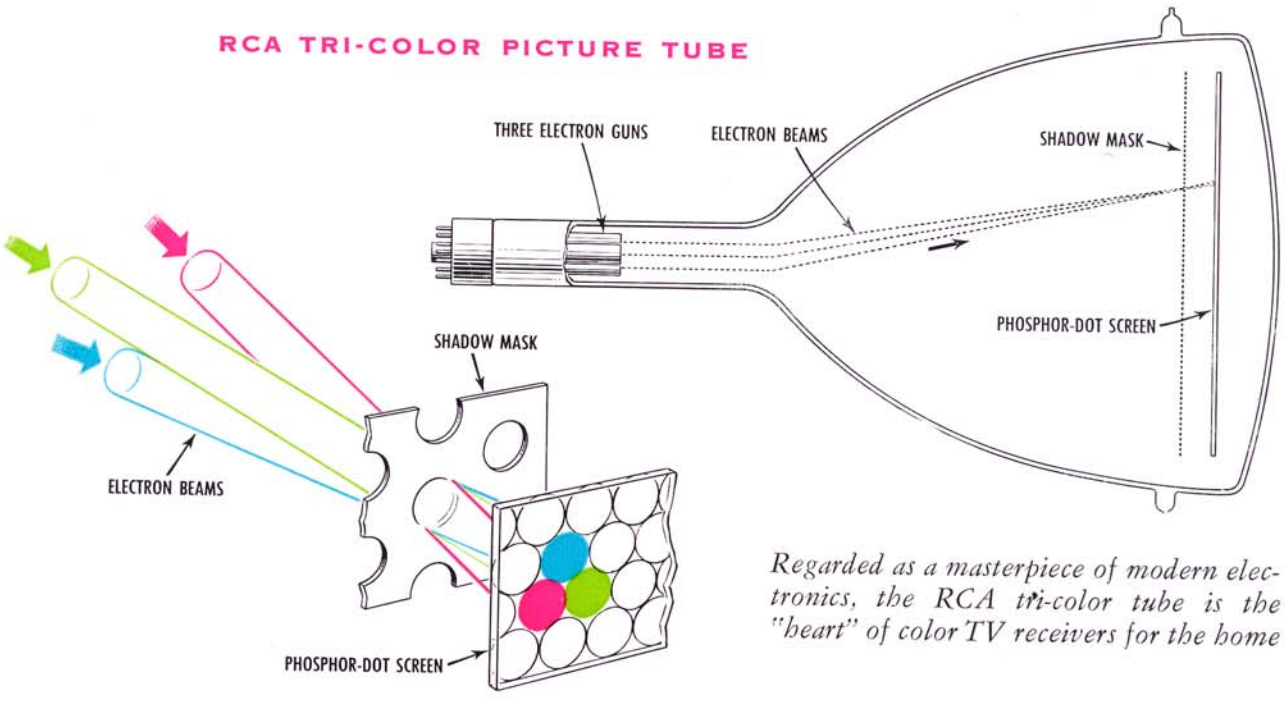
To assemble a complete color signal, the color television camera breaks up the image into three primary colors—red, green and blue. With these primaries any color in the visible spectrum can be described electronically by selecting the proper values of hue, saturation and brightness. In fact, the gamut of colors available to RCA color television is even wider than that achieved by commercial color printing or color photography.

By adding a certain amount of each of the three primary colors, the impression of white can be produced in the eye. Green and red together give an impression of yellow; red and blue results in purple. An absence of all three primaries produces an impression of black.

Color Receivers

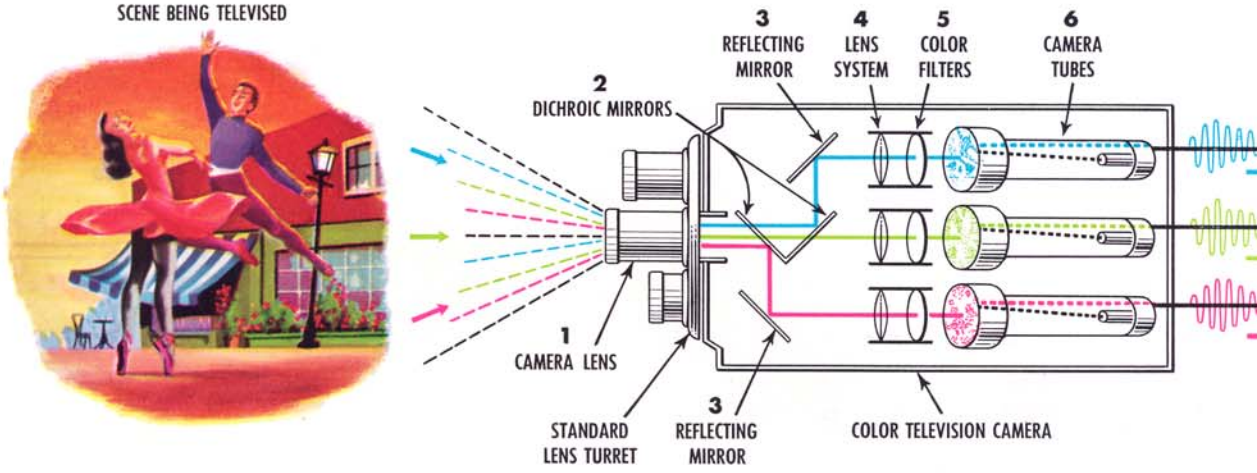
Tri-color picture tubes of various sizes and technical arrangement have been developed and tested by RCA. One version has three electron guns—one for each primary color—which scan and stimulate color phosphors on the viewing screen. The tiny phosphor dots—there may be 600,000 of them or more—are arranged in clusters of three, a red-glowing, green-glowing and blue-glowing phosphor in each group. A shadow-mask between the guns and viewing screen has tiny perforations in it so positioned that the stream of electrons from each gun can fall only on its appropriate color phosphor. The beam that "paints" red information will only strike the red phosphors, and so forth. (See sketch of shadow mask tube.)

RCA has demonstrated direct-view tri-color tubes with pictures approximately the same size as a 14-inch black-and-white rectangular tube as well as larger sizes. Another approach to larger color pictures may lie in a system whereby the color image is projected on a screen. RCA has shown such color television pictures in sizes up to 15 by 20 feet.



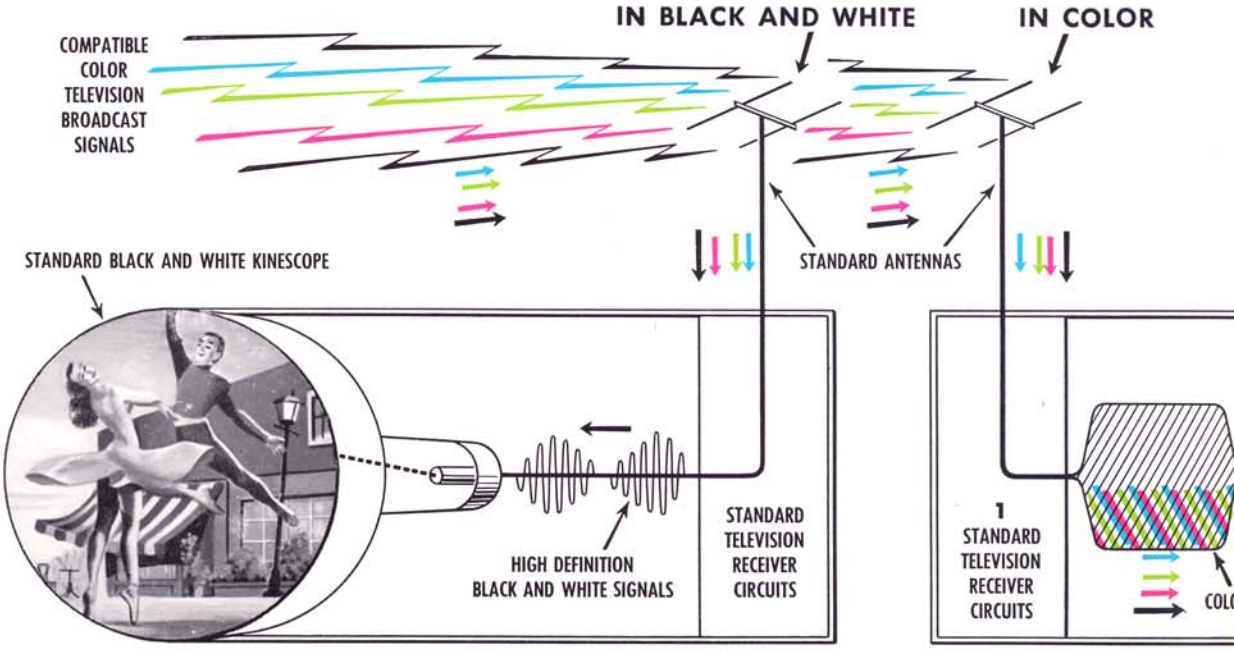
Regarded as a masterpiece of modern electronics, the RCA tri-color tube is the "heart" of color TV receivers for the home

PICKUP AND TRANSMISSION



The lens 1 of the color television camera collects light rays in full color from the scene being televised. The full color image is focused into a series of mirrors. In the center are two dichroic mirrors 2 made of specially treated optical glass which has the property of reflecting one color while passing all other colors. The first of these mirrors reflects the red light, while the blue and green light passes straight through. The second dichroic mirror reflects the blue but passes the green. Thus three images, one in each primary color, are created. With the aid of regular reflecting mirrors 3 and a lens system 4 the three primary images are focused on the faces of three television camera tubes (image orthicons). In front of the camera tubes are color filters 5 which assure that the color quality of each primary has the precise value for the system. The electron beam

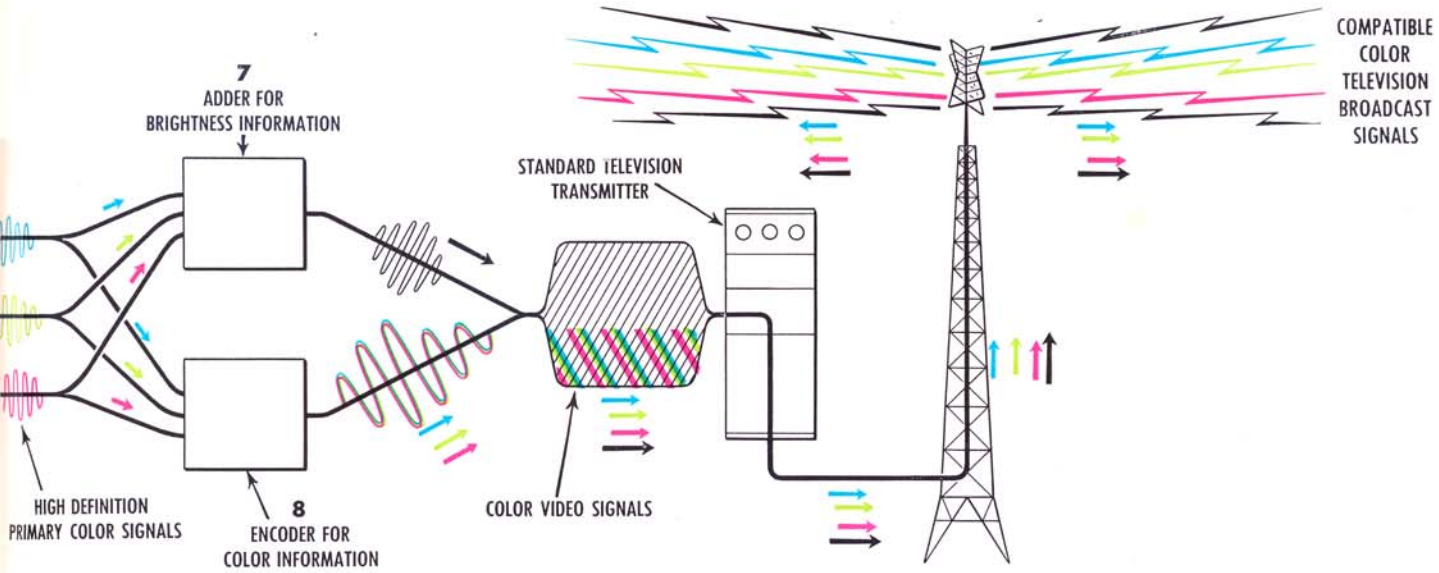
RECEPTION OF RCA



UNMODIFIED STANDARD BLACK AND WHITE TELEVISION RECEIVER

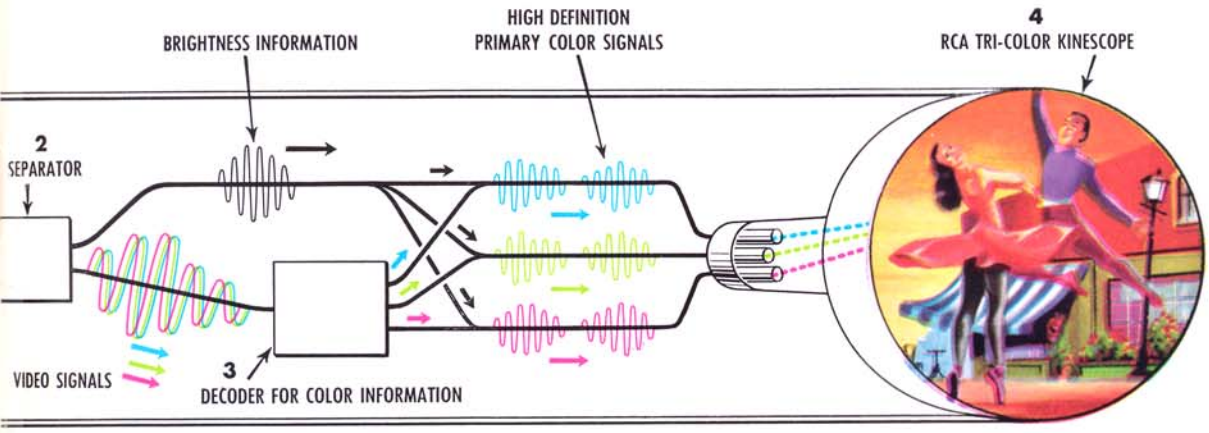
When the color television broadcast signals reach a black-and-white receiver, the electronic data pertaining to hue and saturation are ignored by the receiver's circuits and only the brightness signal remains effective. Unless the viewer were informed in advance, he would not realize that the scene on his kinescope started out from the studio as a signal in full color.

OF RCA COLOR TELEVISION



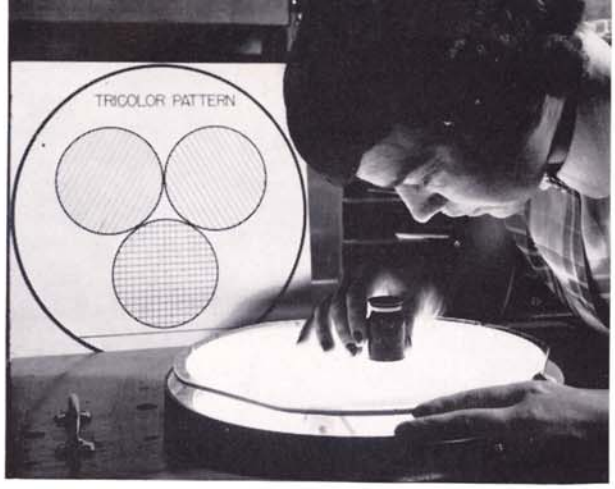
in each camera tube 6 scans the image pattern which has been formed on the tube screen, thereby producing a primary color signal. The three primary color signals from the three tubes are now processed for transmission. Samples of these signals, in proper amounts in relation to each other, go to an electronic adder 7 which combines them to make the brightness, or black-and-white signal. At the same time, samples of the three primary signals are fed to another unit 8 which encodes or combines them to produce a signal carrying the hue and saturation information. This color-representing signal is then combined with the brightness signal to form the complete color television signal. Although the brightness signal and the color-representing signal are transmitted together they do not interfere with each other.

COLOR TELEVISION

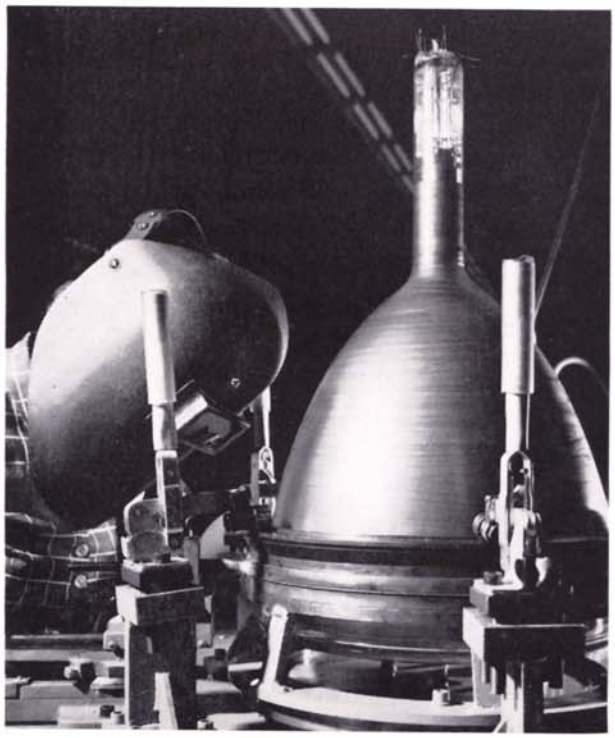


COLOR TELEVISION RECEIVER

When the color television broadcast signals flow down a standard antenna lead-in and through standard television amplifying circuits 1, the receiver separates 2 the color-representing signal from the brightness signal. Next the color information is decoded 3 so that when recombined with the brightness information a series of high-definition primary color signals are produced, ready to be applied to the tri-color tube 4.







For home reception, RCA engineers have experimented with projection color receivers using three small developmental picture tubes (again one for each primary color) which project images through special optical systems onto a translucent screen. A full-color 18-by-24-inch picture obtained by the projection method has been demonstrated by RCA.

The color receivers RCA Victor is producing initially, have a shadow-mask tri-color tube which displays a picture approximately 9 x 12 inches in size. The receiver is simple to operate. It has two more control knobs than black-and-white sets —one for the viewer to adjust color saturation to his own liking, the other to make slight adjustments in the hue of the received picture.

How the Signal Fits a Standard Channel

A television station, whether transmitting programs in black-and-white or in color, is limited to a bandwidth of 6 megacycles. This width was established long before the advent of modern color television. To add color to black-and-white transmissions without exceeding this bandwidth called for intensified research by research scientists and communications engineers.

One of the major savings in bandwidth is possible because the human eye cannot distinguish colors when they appear as small areas. For example, a housewife finds it difficult to match a thread to a piece of material if she uses only a single strand of thread. Experience has taught her that she must rely on a larger surface — the whole spool of thread — for an accurate match. Similarly, one can see an approaching man's necktie long before one sees the individual colored stripes on it.

This limitation of the human eye is made use of in the RCA color system, where channel space is conserved by including all fine details of the image, whatever their hue and saturation, in the brightness signal. This leaves the color-represent-

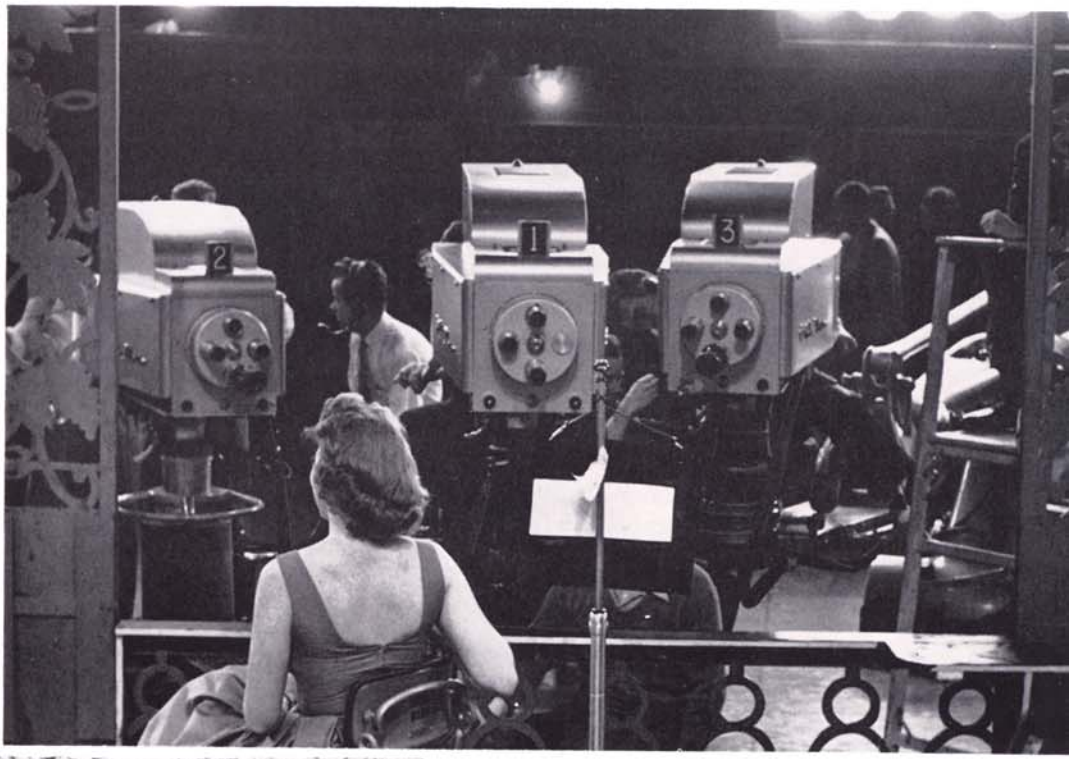
Precision and craftsmanship of highest caliber go into building RCA tri-color tube components

ing signal responsible for defining hue and saturation, in medium and large areas of the color picture. Consequently, the color-representing signal needs to be only a fraction of the bandwidth to satisfy the eye's need for color information. As was pointed out earlier, further saving is achieved by blending the color-representing signal within the brightness signal.

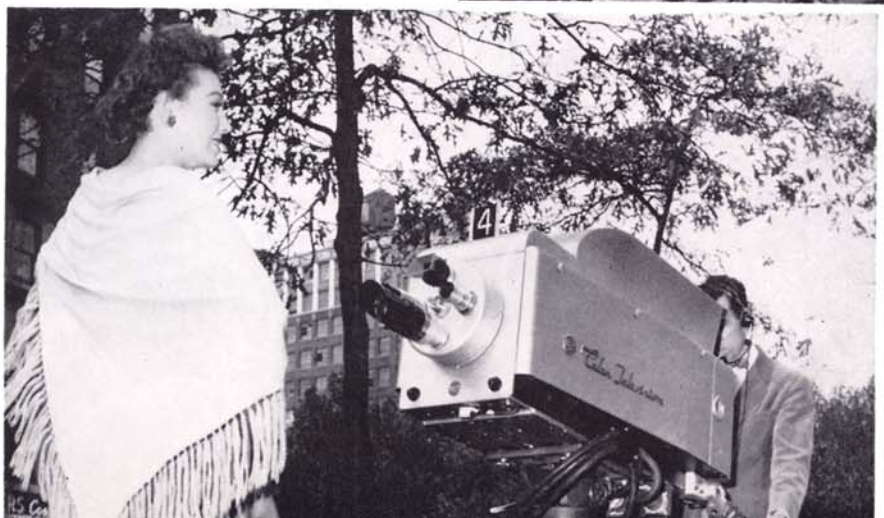
For the Future

The foregoing description of RCA's color television system has considered the operation of a single camera and receiver. Actually, the facilities for a well-rounded operation are more extensive. For example, NBC's Colonial Theatre in New York embodies advances made in several years of field testing and experimental telecasts. In this studio are consoles and monitor equipment to handle four color cameras. The theater's enlarged stage, with its ample facilities for lighting and scenery, and its complete electronic controls provide not only a tried and tested originating point for color television network programs but can function equally well as a versatile setup for continued experimentation and refinement of the color TV art.

For outdoor pickup of sports and news events, NBC has mobile color television units. These have control equipment for monitoring camera pick-ups and for processing the complete color signal. Sig-



Multiple camera units often converge for varied pickups of important studio color scenes



Street scenes can be transmitted with effectiveness that bring to color TV "eye-witness" realism

nals from the truck are fed to a transmitter by cable or over longer distances by a microwave transmitter carried on the vehicle.

Although RCA has developed equipment for excellent color television presentations, research and engineering leading towards simplified and refined apparatus and techiques continues. The work is in the hands of teams formed from the technical staffs of RCA Laboratories Division, RCA Victor Division and the National Broadcasting Company.

Among the promising projects is one to provide a single, compact, simple tube for color television cameras. This tri-color camera tube is being developed as a possible replacement for the three image orthicon tubes required in present-day RCA color cameras. As demonstrated in experimental form, the tube is of the vidicon type, so successful in RCA Industrial Television equipment. It is expected to result in the design of a color television camera no larger than black-and-white cameras. Further, its simpler circuitry should make for easier camera adjustment and operation.

Another RCA research project is to provide a tri-color kinescope which produces very bright color pictures. A developmental model of such a tube, which uses, instead of the shadow-mask, a mask that focuses electron beams onto the phosphors, has already been demonstrated. When it has been brought to a point of commercial practicality, it can be incorporated into the RCA color system without any change in standards.

RCA and NBC engineers are also working on effective ways of providing high quality television programs from color motion picture film, and on methods for making color films direct from images on the screen of a tri-color tube.

For example, RCA has announced a method, still in a developmental stage, of producing programs in color from color film. The system utilizes three recently developed small RCA vidicon camera tubes, used in conjunction with a TV film projector. Besides this vidicon system, RCA Victor has two other methods under consideration for handling color films for color broadcasts. One uses a "fast pulldown" projector and the other uses a continuous type projector.



Stars of the "Kukla, Fran and Ollie" puppet show being televised in color for a network broadcast

NBC "Carmen" telecast in color on October 31, 1953, was a memorable "first" in TV history



RCA NBC | 'Firsts' in Color TV

The foundation for a color television system was laid by RCA's pioneering in research and engineering development of black-and-white television.

Throughout the 1930's field tests and experimentation with black-and-white television continued. In April, 1939, at the opening of the New York World's Fair, RCA-NBC began the first regular television broadcasting service to the public, and RCA Victor introduced television receivers for public use. Fundamental developments in all-electronic black-and-white television provided the base for RCA's pioneering research in color television that led to the following advances:

1940 Color television, produced by electronic means, was demonstrated to the Federal Communications Commission by RCA at Camden, N. J. NBC worked on a field sequential color system and transmitted the first color signals from that system over station W2XBS, Empire State Building.

1941 On December 1, 1941, NBC gave a closed circuit demonstration of color television using a 441-line field sequential system. Purpose of the demonstration was to prove to the FCC that the field sequential system, when limited to the same bandwidth as the black-and-white system, was lacking in resolution as compared to the latter.

1941-1945 RCA-NBC devoted its research and engineering resources to wartime military applications of electronics including television.

1945 RCA demonstrated field sequential color television and 3-D color television to the industry, and started post-war evaluation of color TV.

1945 RCA gave full attention to the development of an all-electronic color television system after further tests and demonstrations proved that a mechanical color system had fundamental limitations. Two main objectives were: High standards of performance, and compatibility with black-and-white TV.

1946 An all-electronic projection type color television receiver with a 15 x 20-inch screen was demonstrated publicly for the first time at the David Sarnoff Research Center of RCA at Princeton, N. J.

1947 All-electronic color television pictures projected on an 8 x 10-foot screen were demonstrated by RCA at Franklin Institute, Philadelphia.

A color television camera for use with the RCA all-electronic color television system was demonstrated to the FCC and others at the David Sarnoff Research Center. Studio and outdoor pick-ups were featured.

1948 RCA continued research and development to improve and simplify all-electronic color television.

1949 RCA informed the FCC it had developed a high-definition all-electronic color television system operating on a 6-megacycle channel and completely compatible with the existing black-and-white television system.

Field tests of the RCA all-electronic compatible color television system operating on 6-megacycle channel, began in Washington, over NBC station, WNBW, and demonstrations were held for the FCC. Tests were conducted in Washington over an experimental UHF station and simultaneously over VHF.

NBC conducted compatible color television tests in Washington, D. C., for the first time during regular broadcast hours. The puppet show, "Kukla, Fran and Ollie", televised by color cameras in Washington, was fed to the NBC-TV network. It was the first regular TV program to be seen simultaneously in color (in Washington), while viewers in other cities on the network viewed the show on standard receivers in black-and-white.

RCA-NBC transmitted color television over a microwave relay loop between Washington, and Baltimore, Md., in a demonstration to FCC.

1950 RCA demonstrated its tri-color tubes and a compatible all-electronic color television system to the FCC, to other government officials and to the industry. One tube utilized a single-electron gun and another three electron guns. The first scheduled color broadcasts were conducted in Washington. Also a new transmission development to make color television programs produced by the RCA all-electronic system available to broadcasters over coaxial cable networks, as well as over radio relays, was demonstrated between Washington and New York. The color images, after transmission over the cable, were broadcast by WNBT, New York on VHF and were also radio relayed to NBC experimental UHF station, Bridgeport, Conn., for rebroadcast.

1951 RCA presented detailed technical and engineering information on its tri-color tube to competing tube and set manufacturers, at a series of meetings it organized to aid in the further development, testing and introduction of color by the industry.

Network color television tests conducted by RCA-NBC, originating in Washington, D. C., were transmitted by microwave relay to New York and rebroadcast to the David Sarnoff Research Center at Princeton, N. J.

Tests of the RCA compatible color television system began in New York over NBC station WNBT. Field tests featured reception on the RCA tri-color picture and outdoor pick-ups by the color television camera.

RCA conducted public reaction tests of compatible color television with receivers in the lounge of the Center Theatre, Radio City. The programs were also produced on a 9 x 12-foot screen at Colonial Theatre, New York.

RCA color television signals originating in New York were transmitted in a test via microwave to Los Angeles and looped back to New York over an 8,000-mile circuit.

1952 Compatible color television tests were conducted in New York for the first time by NBC during regular broadcasting hours. The Colonial Theatre was equipped with color studio equipment making it the first studio in America for large scale color TV programs.

1953 RCA demonstrated its compatible color television system to the Committee on Interstate and Foreign Commerce, House of Representatives, to the FCC and to the industry. A color television camera equipped with a single tri-color tube, instead of three color pick-up tubes, and both outdoor and indoor pick-ups, were demonstrated.

RCA-NBC petitioned the FCC on June 25, 1953 to adopt the compatible technical signal specifications used by RCA color television system as standards for commercial color television.

RCA made available to competing tube manufacturers in the radio-television industry the latest information on design and production of its improved tri-color TV picture tube at a technical symposium in New York, on July 15, 1953.

RCA turned over to engineers representing virtually all television set manufacturers full details of design and performance of RCA's basic color television received at a symposium in New York, on October 7, 1953.

Participating in a color television demonstration for the FCC under the auspices of the National Television System Committee on October 15, NBC presented a studio program telecast, and RCA demonstrated its compatible all-electronic color television system and receiver equipped with the RCA tri-color tube.

An hour production of "Carmen" was telecast in color on October 31 by the NBC television Opera Theatre using the RCA compatible color system.

On November 3, 1953, a live show from the NBC Colonial Theatre studio in New York was transmitted by RCA compatible color television via radio relay to Burbank, Calif., in the first transcontinental color television demonstration; color film was also transmitted by television for the first time.

Magnetic tape recording of both color and black-and-white television programs was demonstrated by RCA on December 1, 1953 at the Princeton laboratories.


RCA