Cathode-Ray Tube
(Heart of Television)

Probably the most significant achievement in the field of vision and electronics was the successful development in 1931 of a commercially practical cathode-ray tube by Dr. Allen B. Du Mont in his basement laboratory in Upper Montclair, N. J. This achievement opened the way for all-electronic television as we know it today, for the cathode-ray tube is the heart of television.

The Telectronic Age

But that astonishing electronic device, the cathode-ray tube, has many, many other vital uses in addition to its presentation of television pictures. It is the indicating device in the cathode-ray oscillograph, a precise measuring instrument used extensively by science and industry. It is the screen for the presentation of information on radar apparatus. Television is now used in a variety of industrial, medical, and scientific applications. From Du Mont's first commercially practical cathode-ray tube in 1931 has come this entire era of vision combined with electronics to produce "The Telectronic Age."

The Du Mont Exhibit at the Department of Commerce Washington, D. C.

Allen B. Du Mont Laboratories had its beginning in Dr. Du Mont's laboratory in 1931 when he first developed a practical cathode-ray tube. Through constant research and development in visual electronics, it now operates in every phase of television. The company is a leader in the manufacture of television picture tubes, special cathode-ray tubes, cathode-ray oscillographs, radar equipment, television broadcast equipment, television receivers, multiplier-phototubes, and mobile radio equipment. In addition it operates three television stations and the Du Mont Television Network. The company employs more than 5,000 people, and occupies six large plants in northern New Jersey, plus television studios throughout the United States.

Included in the Du Mont Exhibit at the Department of Commerce are the following items of historic and current interest in the field of electronics.

- The first practical cathode-ray tube to be developed - made by Du Mont in 1931.
- The first all-electronic television receiver marketed in America - the Du Mont Type 180, made in 1937.
- A display of industrial-type and multi-gun cathode-ray tubes.
- An action display of a cathode-ray oscillograph on which voice patterns of the exhibit visitor are displayed on the face of the oscillograph.
- A display of multiplier-phototubes.
- An action display of a multiplier-phototube in which the light from a radium watch face is multiplied 1,000,000 times and activates a switch to turn an electric light on and off.
- The Du Mont Radar Set, APS 42, used by the United States Navy in military transport operations, using indicating cathode-ray tubes with long persistence screens.
- A Nipkow disc, the mechanical type of television receiver used prior to Du Mont's development of the cathode-ray tube.
- The Du Mont Chroma-sync Teletron - the first large-screen color picture tube to be publicly shown. A 19-inch tube, it was demonstrated by Du Mont in April, 1954.
- A 14-inch black-and-white television picture tube made by Du Mont in 1938 and used in the first all-electronic receivers marketed in America.
- A modern television receiver manufactured by Du Mont - the Belvidere - featuring a Du Mont 21-inch rectangular picture tube and advanced electronic circuits for best fringe area and urban reception. The Belvidere is a full-door console with traditional styling.
- Photographs of Du Mont's color multi-scanner for the televising of color motion picture film; a photo of a modern Du Mont image-orthicon television camera.

Patents

Certainly the growth and development of Du Mont Laboratories and its technical achievements reflect the progress that is possible under the United States Patent System. The Du Mont Exhibit at the Department of Commerce reflects the product of many patents dealing with improvements in processes or design of cathode-ray tubes, color television picture tubes, certain radar principles, television cameras, principles of television receiver design, and cathode-ray oscillograph circuits.

As of January 1, 1954, Du Mont owned 205 United States patents and 181 more were pending - most of which deal with some aspect of visual electronics.

DU MONT

Allen B. Du Mont Laboratories, Inc.
750 Bloomfield Ave., Clifton, N. J.

DU MONT

VISION

THE DU MONT DIMENSION IN ELECTRONICS

Eight short years in our industrial history have seen the birth of a new age - The Telectronic Age. In that time vision has been brought to the electronic art - and vision has been added to broadcast reception in 32 million homes throughout the country. In 1946 there was no television industry. Today - it provides employment to hundreds of thousands of our citizens. It provides entertainment, education, and information to millions. It is pointing the way to more efficient, lower cost industrial operations.

Importance of Patents

How did it come about? What was the background that brought this scientific marvel to the homes of America? Dr. Allen B. Du Mont, television pioneer and president of Allen B. Du Mont Laboratories, Inc., has stated, "The protection afforded by our United States Patent System supplies essential incentives to industrial, scientific, and economic progress."

There is little question that our country's leadership in standards of living, modern conveniences, and in industrial progress are all directly traceable to the potential for reward inherent in new developments under the United States Patent System.

Historic Television Developments

The bringing of Vision to the art of electronics is the result of development and discoveries by many men - dating as far back as 1880. The first television patent was filed in that year in England. Although not practical for actual use, that system was the forerunner of the thousands of patents that have refined and developed the electronic art to the point that pictures or data can now be broadcast and reproduced in detail on the face of a cathode-ray tube (television picture tube).

CONSULTANTS

ERNEST O. LAWRENCE, Director, Radiation Laboratory, University of California.

LUIS W. ALVAREZ, Professor of Physics, University of California, and member of the staff of the Radiation Laboratory since 1936. Discoverer of Hydrogen 3, one of the most important radioactive isotopes. Inventor of protin linear accelerator. Inventor and developer of Ground Control Approach (GCA), a blind aircraft radar landing system.

EDWIN M. McMILLAN, Professor of Physics, University of California, and member of the staff of the Radiation Laboratory. Awarded Nobel Prize for Chemistry (1951) for discovery of transuranium elements. Inventor of synchrotron, an electron accelerator.

FERENC OKOLICSANYI, television pioneer and consulting physicist, London, England. Holder of many patents in the fields of television and electron optics.

MILTON G. WHITE, Professor of Physics, Princeton University, and in charge of nuclear physics research activities.

J. DONALD GOW, staff member, Radiation Laboratory, University of California. In charge of linear accelerator group.

JAMES T. VALE, staff member, Radiation Laboratory, University of California. In charge of 184-inch cyclotron operation.

CHROMATIC TELEVISION LABORATORIES, INC.

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the Lawrence Tube, have embraced a complete theatre television system, microwave studies and research on special optical systems. The Chromatic organization is thus experienced in the field of cathode ray tubes, electromagnetic phenomena and electron optics, film processing, optics and communication electronics in ultra-high and microwave frequencies.

In developing the Lawrence Tube, Chromatic has pioneered in the study and development of phosphors and phosphor deposition techniques, high vacuum techniques, electron optics and many other related fields. It has built and developed associated equipment including special wide-band receiver circuits, wide-band, high-linearity color transmission equipment, wide-band distribution equipment and high vacuum systems.

CHROMATIC TELEVISION LABORATORIES, INC.

Chromatic Television Laboratories, Inc. was organized in February, 1950 to carry on development of color television inventions held by Gaither and Company, a San Francisco partnership. Paramount Pictures Corporation owns 50 per cent of the capital stock; the other half is owned by Gaither and Company.

Chromatic absorbed the staff and facilities previously maintained by the Television Engineering Department of Paramount Pictures. Paramount has long had an active interest in television. It has operated television stations since 1941 and pioneered in the development and operation of theatre television. Besides developing the Lawrence Color Tube, Paramount owns approximately one-third of Allen B. DuMont Laboratories, and approximately 50 per cent of International Telemeter Corporation.

Chromatic maintains offices, television studios and laboratories in New York, the West Coast Development Laboratories at Oakland, California, and recently inaugurated a manufacturing plant at Emeryville, California. The Corporation's research and development projects, besides

course, dependent on more factors than just the picture tube. The circuits of sets vary, the design and material of cabinets, the production and distribution methods of the makers. Just as in the case of present black-and-white sets, therefore, the price of color sets will probably vary greatly.)

Certain characteristics inherent in the single-gun Lawrence Tube design indicate, however, that costs of the set may be kept down. For instance, it has recently been shown that the Lawrence Tube itself can perform certain functions in the reception of a color signal that can only be performed through added circuitry where a three-gun mask tube is used.

In short, the problems involved in the mass production of the Lawrence Tube and of the receiving set employing the Lawrence Tube are much simpler than those confronting the maker of three-gun mask tubes and sets using them. Consequently, those sets with a Lawrence Tube will cost less, will provide a much larger picture than sets with three-gun, perforated mask tubes, and will be simpler and less expensive to keep in operation.

Licensing negotiations are going on with other tube manufacturers both in the U. S. and other countries.

Chromatic has delivered Lawrence Tubes to all the major receiver and tube manufacturers in the industry. Accelerated programs are under way on receiver designs utilizing the tube.

MASS-PRODUCED TUBES FOR LESS THAN $100 EACH

It is estimated that even with no other advantage, differences in yield of saleable tubes from each thousand built would result in the single-gun Lawrence Tube costing only 60% of the price of the three-gun mask type. Pilot plant production indicates that it should be possible to mass produce 24-inch Lawrence Tubes at a cost of less than $100 each. This estimate is based on the relative simplicity of manufacture, and also the fact that experience has already shown Lawrence Tubes can be made with a rejection rate much lower than that experienced in building other types of color tubes.

(Prices, however, can vary with the production techniques and problems of the individual manufacturers of the tube. The total cost of the color receiving set is, of

CHROMATIC'S LICENSING ARRANGEMENTS

Chromatic Television Laboratories, Inc., developers of the Lawrence Tube in consultation with Professor Lawrence, does not manufacture receiving sets or color tubes in quantity. However, it makes licensing agreements with cathode ray picture tube manufacturers, who in turn are providing tubes for set manufacturers.

(Chromatic has begun the manufacture of "Chromopac" color grids for the 21-inch and 24-inch Lawrence Tubes in its new plant at Emeryville, California, in connection with its West Coast laboratory.)

First to sign a licensing agreement to make the Lawrence Color Tube was the Crosley Radio and Television Division, Avco Manufacturing Company, in November 1953. At that time, Leonard F. Cramer, Vice President of Avco, announced that his Company would produce the Lawrence Tube in its Batavia, Illinois, plant where a pilot production line for color tubes is now in operation.

In December 1953, Thomas Electronics, Inc., the nation's largest independent manufacturers of cathode ray tubes and a supplier to many of the major set producers, also signed a licensing agreement to make the Lawrence Color Tube.

has been successfully demonstrated to industry engineers at CTL's West Coast laboratories.) The large picture size and short tube length of the Lawrence Tube is possible because the post-deflection focusing and switching techniques inherent in its design permit wide angle deflection.

Because the Lawrence Tube utilizes 85% of the electron beam -- with not more than 15% interrupted by the wires in the grid -- the Lawrence Tube produces a picture that is relatively much brighter than those of mask type color tubes.

At an anode voltage of 18KV, the brightness measured through a 66% efficient filter face plate is above 50 foot lamberts in the highlights, which is regarded as fully adequate for home TV viewing.

Demonstrations of the Lawrence Color Tube that have been given in brightly illuminated rooms show that even such conditions do not detract from the brilliance of the picture.

24-INCH COLOR PICTURE WITH ONLY 25-INCH TUBE DEPTH

There is a popular misconception that color picture tubes necessarily must be smaller than black-and-white tubes that the public has become accustomed to viewing. This erroneous impression has resulted mainly from the attention given the perforated-mask color tube, which from a practical standpoint requires a length of 26 inches and a round bulb having a diameter of 15 inches in order to produce a 12-1/2-inch picture. A larger picture of this kind might require a proportionately longer tube and presents a more difficult registration problem.

A 21-inch Lawrence single-gun tube with an 18-inch picture, on the other hand, has been in pilot production for some time and is only 22 inches long. This results in a picture over 70% larger than that of the mask tube, displayed in a 15% shorter tube.

Late in 1953, Chromatic Television Laboratories began experimental production of a 24-inch rectangular model of the Lawrence Color Tube, which could be the standard size of the mass-produced Lawrence Tube licensed to set makers. (The 24-inch rectangular model

ADVANTAGES OF THE LAWRENCE SINGLE-GUN TUBE

TO THE CONSUMER:

1. Larger color pictures.
2. More brilliant picture because it makes maximum use of electrons.
3. Stable color picture because of simplicity of receiver circuits.
4. Better, sharper black-and-white picture.
5. Simpler controls.

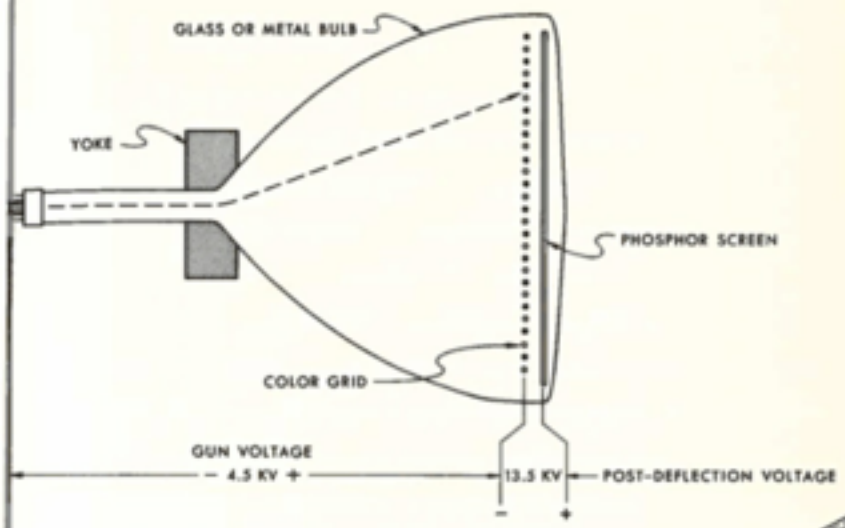
TO THE RECEIVER MANUFACTURER:

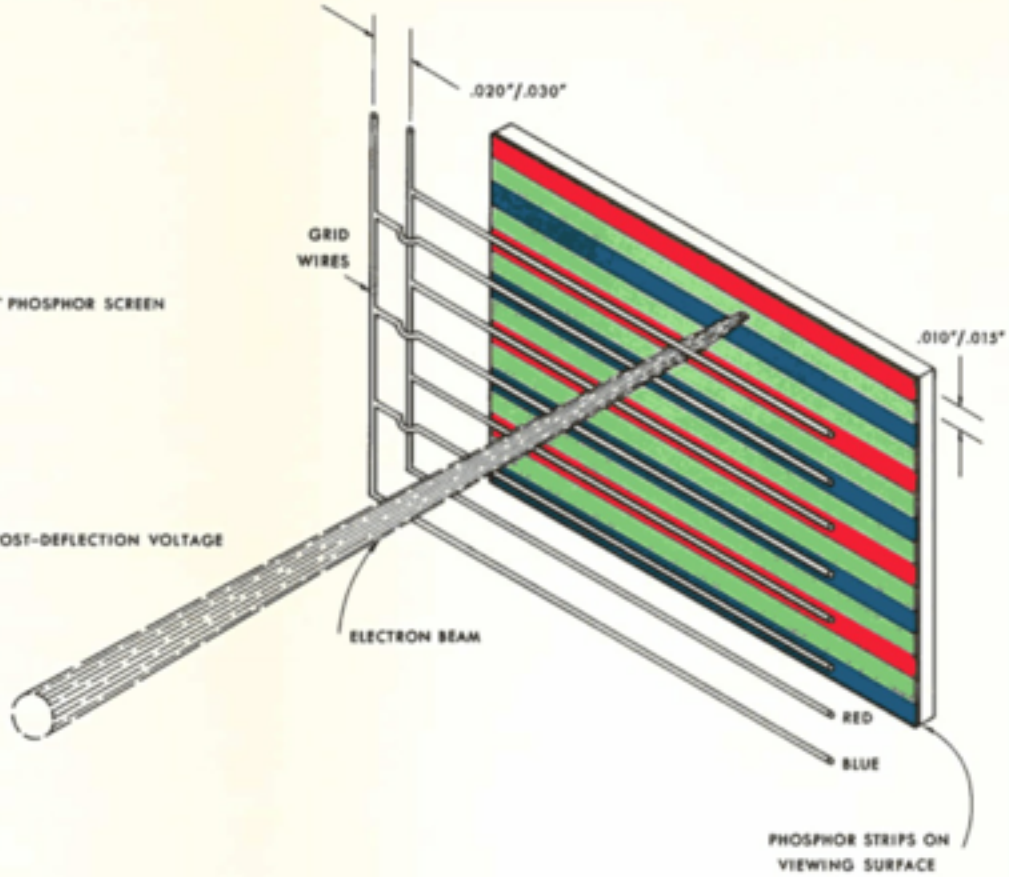
6. Smaller and less expensive cabinet because its wide deflection angle makes the Lawrence Tube a shorter tube.
7. Standard deflection and focus components.
8. Low raster scanning power.
9. Simple low-cost circuitry.
10. Quick circuit alignment.
11. No power supply regulation.
12. No color purifying coils or registration magnets.
13. No Mu metal sheet needed to shield tube from the earth's magnetic field.

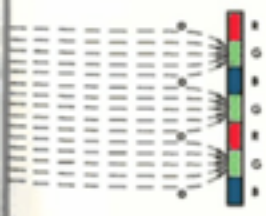
TO THE TUBE MANUFACTURER:

14. Lower scrap rate and easier manufacturing because its design allows tolerances less critical than other types of color tubes.
15. Manufacturing techniques that are very close to those for existing black-and-white tubes.
16. Cheaper and fewer parts.
17. Lower total manufacturing costs for larger color pictures.
18. Greater profit margins.

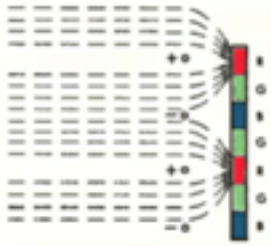
CHROMATIC TELEVISION LABORATORIES, INC. NEW YORK







UNDEFLECTED ELECTRONS STRIKE GREEN PHOSPHOR STRIPS.



VOLTAGE APPLIED TO COLOR GRIDS WITH POLARITY SUCH AS TO DEFLECT ELECTRONS TO RED PHOSPHOR STRIPS. OPPOSITE POLARITY PRODUCES BLUE.

PDF SINGLE-GUN

LAWRENCE TUBE (CHROMATRON)

by Chromatic and by tube and receiving set manufacturers. Chromatic's engineers feel that the single-gun tube will ultimately be the choice of the industry, although three-gun Lawrence Tubes have been successfully demonstrated. All of these tubes embody the basic principle of post-deflection focusing which makes it possible to build color stability into the tube itself.

Chromatic has followed an aggressive program of patenting the inventions of Professor Lawrence and of its other consultants and employees, and has in addition acquired underlying patent rights which it considers basic to the Lawrence Tube in all its forms.

Chromatic has from an early date also done development work on beam-indexing tubes. These tubes control the registration of the electrons and phosphor strips by means of pulses generated when the scanning beam strikes conductors between adjacent groups of red, green, and blue phosphor strips. These pulses time the releases successively of red, green and blue video signals.

One of the greatest advantages of the Lawrence Tube is that it conforms to many standard monochrome cathode ray tube manufacturing processes. With the exception of the wire grid and the color phosphors on the viewing screen, the single-gun Lawrence Tube does not differ in appearance from the standard black-and-white tube. Similarly, it makes use of important and standard components of black-and-white tubes.

It has been proved that the circuitry for a receiver using a single-gun tube of the Lawrence type is less costly and complex than that required for a three-gun mask tube.

Improved methods of depositing the color phosphors in the tube have permitted Chromatic to increase the number of phosphor lines so that resolution is now comparable to black-and-white tubes.

The manufacture of "Chromopac" grids has not only been simplified, but the design has permitted a practical solution to the re-radiation problem. Field tests indicate that field strengths are limited to well under the 15 microvolts per meter at 100 feet generally accepted as the maximum radiation allowable.

Several versions of the Lawrence Tube have been built

electron beam to a small spot. The electron lenses are formed by a wire grid acting in association with a metallic coating behind the phosphor plate. A large voltage difference applied between the grid and the metallic coating, with the coating positive, acts to form the series of converging electron lenses, one between each adjacent pair of grid wires and the screen. This action is called Post Deflection Focusing (PDF) and the Lawrence Tube is often referred to as the PDF tube.

In the single-gun version the electron beam, in addition to focusing according to the PDF principle, is switched to strike the differently colored areas of the screen by means of switching voltages applied between interleaved groups of the wires which make up the focusing grid. The combination of the PDF principle and this grid switching, in conjunction with a correctly-adjusted location of the color areas on the screen with respect to the meshes of the grid, results in the high degree of color registration which characterizes the Lawrence Tube.

Among the important characteristics of the series of electron lenses is that they enable at least 85% of the incident electron beam to be turned to useful light output.

It would offer maximum simplicity and ease of manufacture and operation.

Dr. Lawrence is the inventor and developer of the cyclotron and other types of atom-smashers. He is Director of the University of California's Radiation Laboratory, established in 1932 to house the cyclotron that he had developed. He won the Nobel Prize for Physics in 1939, and during World War II and since has made major contributions to the development of the atomic program. He is consultant to Chromatic Television Laboratories, Inc., developers of the Lawrence Color Tube.

There had been a great many prior proposals for color television tubes when Professor Lawrence entered the picture. But where receiver and tube design was concerned, all of these proposals were characterized by great complexity and high cost. He set out to overcome these two barriers to wide-scale use of color television.

THE USE OF ELECTRON LENSES

The Lawrence Tube (Chromatron) is the result. Basic in its design and operating features is a series of converging electron lenses near the viewing screen to focus the

energy absorbed turns to heat which can cause warping and hence color contamination because the holes are no longer properly aligned with the phosphors. The electron guns must be carefully positioned so that discrepancies between them will not result in color fringing.

To produce a picture comparable in size to present black-and-white sets -- 21 inches and up -- requires either a tube of prohibitive length (since there is a very narrow deflection angle in the mask-type tube) or additional components of a complicated and costly nature.

PROFESSOR LAWRENCE'S CONTRIBUTION

The task Professor Ernest O. Lawrence undertook was to find a simple solution to automatic color registry, and one entirely different from all other approaches that had been explored up to that time.

He set out to construct a tube that would have these characteristics:

It would have no practical limitations as to size or brightness.

It would conform to accepted standards for tube length and rectangular bulb shapes.

of the phosphor screen and putting a hole into this wall directly before the phosphor dot. If an electron is aimed properly to the phosphor dot it will pass through the hole and strike the phosphor. On the other hand, if an electron from the "green" electron gun were incorrectly aimed to strike a red or blue phosphor dot it would be intercepted by the wall or mask.

LIMITATIONS OF THE "MASKING" METHOD

Despite many years of intensive development, certain limitations have proved inherent in this approach to color tubes. Some 85% of the total electrons available are intercepted by the mask. The remaining 15% of the incident beam passes through the mask, and a minimum of electrons strike the phosphor-dotted screen to produce a color picture of low brightness.

Again, the masked tube is necessarily an extremely complicated device. The perforated mask must be adjusted and kept adjusted, and it is particularly difficult with the "masking" technique to keep the red, green and blue beams in color registry.

Because the mask intercepts so many electrons, the

EARLY APPROACHES TO THE PROBLEM: THE "MASKING" TECHNIQUE

An early approach to color TV picture tubes successful in small sizes, used a "masking" technique to be sure that electrons strike the right colored phosphor on the viewing screen. The outgrowth of this technique is the shadow mask type of color tube. The procedure here is to shoot an electron beam from one or more electron guns to strike a phosphor dot 1/100th of an inch in diameter on the face of the Cathode Ray Tube.

The "mask" is a perforated sheet with approximately 200,000 holes. In one tube, for example, three electron guns shoot their beams from different directions through these 200,000 holes onto 600,000 phosphor dots -- 200,000 dots each for the red, the green, and the blue. These dots are so arranged in juxtaposition to the holes in the mask that a portion of the electrons fired from the "red" gun, for example, can get through the mask only to the red dots on the screen, the green only to the green, and the blue only to the blue.

The masking technique seeks to solve the problem of color registration and purity by erecting a wall in front

THE FUNCTION OF A COLOR TUBE

The work of the ordinary monochrome tube is to translate electrical impulses into minute areas of varying shades of black-and-white to form -- according to a pattern defined by the broadcast signal -- an image on the tube's screen.

The function of the color tube is the same, except in addition to reassembling the picture by the placement and light gradation of the minute areas, it must do another job: it must reassemble the picture according to the color values of the minute areas. To do this the tube must be equipped to handle the three primary colors of red, green and blue. The phosphor screen of the set can be divided into these primary colors, but the problem is to get the right combination of luminosity in each of the three to reassemble the pattern of a color image.

(Red, green and blue are "additive" primaries, meaning that lights of these colors can be so added as to produce white or any other color -- for example, red and green light add to give yellow. The primaries of red (magenta), yellow and blue (cyan), learned in school, are "subtractive" primaries, as used in mixing paints. "Subtractive" here means that part of the white light is taken away or absorbed to produce variations in color.)

SECOND, that the price of a large-tube color receiver will be within the means of a mass market. (21-inch monochrome receivers today may be bought at prices ranging from $180 - $350.)

THIRD, that the tube and set will be simple enough to assure minimum maintenance expense. (Today's monochrome sets have maintenance problems that are minor and inexpensive compared with upkeep difficulties in the early days of black-and-white TV.)

There have been at least one hundred proposals for different types of picture tubes for color television in the last twenty-five years. But there is a growing opinion in the industry today that of all those proposed, only the Lawrence Tube promises to meet the public's expectations of large size and low price.

Lawrence Tubes are being made in 21-inch and 24-inch picture sizes to fit rectangular glass or metal bulbs, and there is no reason, practical or theoretical, why the Lawrence Tube cannot be made to match the size of any large black-and-white tube.

THE LAWRENCE COLOR TUBE

When mass production of black-and-white television receivers was started, picture size for most receivers was limited to 7 and 10 inches, and sets were priced at approximately $300 or more. Sets with 15-inch and 20-inch tubes were available from at least one manufacturer at prices well in excess of $1,000. But the appearance in quantity of receivers providing large pictures soon rendered the 10-inch sets obsolete. Pictures rapidly increased in size and sets came down in price. As this occurred, millions of black-and-white receivers were eagerly bought by the public.

This history of black-and-white television development has persuaded many people that the pattern will be repeated with color television receivers -- perhaps even more rapidly with color than with black-and-white.

The swift development and acceptance of black-and-white (monochrome) television has led the public to expect the following things in color TV receivers:

FIRST, a large picture tube. (The majority of black-and-white TV receivers sold today have picture tubes 21 inches and up in size.)

ERNEST ORLANDO LAWRENCE

Nobel Prize-winning physicist, inventor of the cyclotron, who developed the Lawrence Color Tube (Chromatron). Professor Lawrence is director of the University of California's Radiation Laboratory. He is a member of the Board of Directors of and a consultant to Chromatic Television Laboratories, Inc.

THE LAWRENCE COLOR TUBE

(Chromatron)

The first practical color television tube with no limitations on picture size. Now being made in 21-inch and 24-inch models.

Production Model Lawrence 21-inch all-glass tube -- only 22 inches long.