MECHANICAL VS. CATHODE TELEVISION SYSTEMS

Comparative cost, size, complexity, efficiency, features, and physiological effect on the person viewing the image, are discussed.

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THERE IS a great deal going on in television that is new even to the workers who have been long immersed in the problems of the laboratory. These new developments are mainly in the theoretical state; such for example, as the flying spark, the oscillating crystal and the multicellular systems. It is reasonable to say that they add ideas to the television art, which had borrowed much of its thought and equipment from many other arts, but nevertheless it is also reasonable to say that as we view the picture today, the race is to be run and the winner is to come from one of two schools.

TWO SCHOOLS OF TELEVISION THOUGHT

These two schools are represented by the advocates of (1) the Braun cathode-ray and the advocates of (2) the mechanical systems. In particularizing the reference to the cathode ray, I refer to its inventor Braun, who dates back almost as far in the art as does Nipkow, pioneer among the devisers of mechanical systems. So little attention is given to this German scientist Braun that I find many television engineers seem unaware of his vital contribution.

We all know that whichever system—the Braun cathode-ray or the mechanical system—proves the best commercial answer to the problem, this system will be ultimately adopted, because television inherently is, and must be, built on a single pattern; a single type, that is, insofar as the technical equipment is concerned. That there will be considerable waste of investment in order to make this choice, seems to be inevitable. Whoever buys a receiver based on the cathode-ray principle will be left holding the bag should the mechanical system become triumphant. Likewise will this be true in the case of all who buy receivers built on the mechanical principle should they at a later date find the cathode-ray system is adopted.

As far as the investment in transmitting equipment is concerned, no tears need be shed in either case, because transmitter installations will be of sufficient flexibility to enable them to be altered to another form of system at a comparatively minor expense. Personally I believe in the "vibratory" mechanical system and cannot conceive how the cathode-ray system will be eventually triumphant.

Fundamentally all television sets have many parts and (Continued on page 126)
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functions in common. They are primarily differ-
entiated by the way in which they scan or sub-
divide an object at the transmitter, and the
form of scanning they employ at the receiver
to reassemble the picture from the received elec-
trical pulses. Therefore our first point of in-
quiry should be directed at the comparison of the
two types of scanners.

CATHODE-RAY AND MECHANICAL
SCANNER FUNDAMENTALS

The cathode-ray system employs a large
evacuated glass tube on the end of which is a
fluorescent screen, and upon this screen a fine
cathode-ray "pencil" paints a picture. The il-
lumination comes directly from the power of the
cathode-ray beam. The beam travels over a
determined geometrical pattern under the
influence of magnetic or electrostatic pairs of scanning
electrodes. A number of large radio and electrical
companies in the United States have been work-
ing on the cathode-ray tube for the past 5
years and have spent vast sums on its develop-
ment.

In the mechanical systems there is a physical
motion of one or more parts. The light from a
steady source modulated by a Kerr cell is project-
ed from a revolving optical element to a screen.
The mechanical motions used are either rotary
or oscillatory. The former has been generally
abandoned because of the multiplicity of optical
systems it requires and the resulting high cost,
leaving for practical consideration only the os-
cillatory or vibrating type. The scanner shown in
the heading illustration is the Priss scanner and is
of the vibrating-mechanical type. Dr. de Forrest has
told me he believes it to be the only
satisfactory high-definition scanner so far
devised. (Additional illustration and description of
this unit appear on pg. 123 of the August 1935,
Television Number of Radio-Craft—Editor)

In the following, I am setting down the claims
made by the cathode-ray and vibratory-mechanical
systems, in the hope that they will give the
public an insight into the relative merits of the
rival systems.

DEFINITION

The quality of a television picture is depend-
ent directly upon the number of areas into
which the subject is broken, providing that the
pictures are repeated with sufficient rapidity
to give a smooth continuity. Other than the scan-
er itself there are 2 factors that limit the de-
tail or the dot frequency. The first is the width
of the sideband that the Federal Communications
Commission is likely to permit, and the second
one the limitation imposed by the ampli-
fier in the receiver. Latter limitation is serious
and for an amplifier of high gain within the
low-cut-off wave might set its upper limits at
about 2 megacycles. Of course with time this
range will be extended.

Both the cathode-ray scanner and the Priss
mechanical scanner can be built to the upper
limits of the amplifier range and beyond.

There is no real upper limit to the rate at
which a cathode-ray tube can be made to scan,
but this property is of little value because its
practicability is blocked by the amplifier. Such a
class as "1,000 lines" is misleading, for the
amplifier to which the tube must necessarily be con-
ected will not pass more than 250 lines! And
again, if such an amplifier could be built, the
sidebands required would be so great that the
Federal Communications Commission would hesi-
tate about the allocation of such a huge slice of
the ether to a single station.

As a practical matter therefore, the detail or
quality of both systems is the same. Other sys-
tems which cannot meet this standard of quality,
fixed only by the amplifier limitations, have no
place in home television.

PICTURE SIZE

The size of a cathode-ray picture is limited by
the size of the evacuated tube which carries
the screen upon which the picture is painted.
Pictures 6 x 8 ins. and some 8 x 10 ins. are
shown. Larger pictures about 12 x 14 ins. are
produced by the combination of an optical system
in conjunction with a tube operated on high
pressures of 3,000 to 10,000 volts.

The mechanical system operates on a simple
projection principle, that is to say that the field
of light subtends a solid angle whose apex coin-
sides approximately with the optical element. Since
this angle can be readily made 20 deg. (or a 5 deg. motion of the optical ele-
ment on either side of the received electro-
pic pulse), pictures 3 ft. on a side can be projected at a
distance of about 6 ft. from the scanner.

This difference in picture size, that is to say the
inferiorly small size of the picture produced
by the cathode-ray, and the large picture produced
by the mechanical system is a point of very
important. I do not believe—other things being equal—that the public will choose a small
picture system when they have the opportunity of
purchasing a large picture device. They have
been trained to theater and home motion. There
are the standards upon which their judgment is
based. Can anyone imagine a typical movie fan
spending an evening peering through an old-
 fashioned peep-hole machine of the variety found
in the shooting galleries, in preference to en-
joying a modern projected picture?

PICTURE BRILLIANCE

The illumination of a cathode-ray picture is a
function of the impact energy of a stream of
electrons upon a transient fluorescent screen.
The illumination of a mechanical picture is a
function of the brightness of the steady source of
light and the area of the vibrating optical
system.

The factors that limit the brightness of a
cathode-ray picture are of great interest. Since
the screen must be translucent, the area of the
fluorescent material must be thin. If the voltage
applied to the tube is pushed up to increase the
brilliance, the violence of the bombardment of
the screen rapidly destroys it. Furthermore all
of the power for the illumination must come from
an amplifier that is flat from a low frequency
to the limiting frequency of a scanned dot. This
power is most expensive and requires a large
amplifier output of peak power of several
thousand volts. In other words, the limits are set
by the burning-out of the screen on the dot has
begun, and the cost of the apparatus for producing a
very high voltage of broad band characteristics
on the other. However, the brilliance is adequate
for the small-size pictures now produced, but is
distinctly inadequate for a substantial optical
expansion of the picture.

The mechanical system functions in an entirely
different manner. The light is steady; and sup-
plied from an inexpensive power source. Only a
small amplifier power is required to modulate it;
and this power is delivered at medium potentials.
One limitation to the brilliancy is the intensity of
the source. There is available an enclosed source
that has a brightness greater than that of the
face of the sun. This lamp is small and inexpen-
sive, and has a long life. (See the article in this
issue of Radio-Craft, by Dr. de Forrest)

The second limitation is the area of the moving
optical system upon which the beam impinges before being projected to the screen. Using the
mentioned light source and a mirror of 3/16-in,
in, with an optical system of an overall efficiency
of about 22 per cent, the illumination is adequate
for a 3 ft. picture; smaller pictures are corre-
spondingly brighter. The 3/16-in. in. size mirror
requires 1A. at 1/2-V. to drive it. Larger mirrors
can be used with a corresponding increase of
driving power.

The story is not told completely by merely
comparative brightness. The quality of the light
and its physiological effect enter. The pictures
produced by a cathode-ray tube is usually a green-
gray. The picture produced from the mechanical
system using a steady light source modulated by
a Kerr cell is generally white-gray to white-black.
The cathode-ray picture tires the eyes and causes the
observer after prolonged programs to find his eyes recording drifting spot areas when view-
ning objects other than the picture. This pheno-
menon does not occur with the mechanical sys-
tem, that is to say, with the mechanical system
the physiological effect is the same as that result-
ing from viewing an ordinary black and white
motion picture.

Generally the lighting problem favors the me-
chanical system in respect to the attainable brilli-
ance for equal screen areas, the amount of
broad-band power required for a given brilli-
adiation, the size of the respective screen element, the potentials that must be generated by the
amplifier, and the physiological effect.
SCANNING CIRCUITS AND SYNCHRONIZATION

Both systems drive their scanning or amplifier power controlled by a modulation of the carrier wave. In the case of the cathode-ray system, the scanning is performed by applying 2 high potentials of the order of 1,000 V. to corresponding pairs of electrodes, or in other words by electrostatic control. In the mechanical system the scanning is performed by supplying 2 magnet systems with a predetermined number of ampere turns excited at potentials of the order of only 10 V. It is much less expensive to construct supply circuits of low voltage than it is to build corresponding circuits of high voltage.

But there is a more basic difference involved. The cathode-ray beam is practically inerterless and follows exactly the shape of the wave impressed upon its control electrodes. If this waveform varies from the pattern employed at the transmitter a corresponding picture distortion is introduced.

In the vibratory-mechanical system the motion is harmonic as are all of man’s other recurring, predefined, constant-time-interval mechanisms. The scanners have an inherent period in each direction, dependent upon the designed moment of inertia and cooperating elasticity of each of the systems of motion. In operation they have a comparatively tremendous amount of energy stored up when compared to the increment of energy supplied by each driving pulse. They automatically tend to keep in step with the transmitter, and the waveform of their driving power is of no consequence upon the matter of picture distortion due to this great energy storage. It must bear in mind if there is a slight difference in the natural periods of the scanners, that under the influence of a driving pulse on each swing, they will follow the period of the driving pulse and not their own, slightly off-resonance natural period. With a control of amplitude and phase at the receiver an exact framing and synchrony can be obtained.

The type of driving power favors the mechanical system. Furthermore, in spite of the variations that may be introduced by off-resonance, which variations can be compensated for at the receiver, the inertia inherent to the mechanical system eliminates a cause of distortion to which the cathode-ray system is sensitive—that of reproducing every slight ripple and surge in the base timing (scanning) voltage—because its beam lacks elasticity and inertia.

COMPARATIVE COSTS

It is not quite in balance to compare the cost of a small cathode-ray picture with the cost of the large picture produced by the mechanical system. However, cost is a vital factor and must be considered at least on the basis of the physical receivers that both systems propose to offer the public.

Starting with the scanner, the cathode-ray tube, like an incandescent lamp, is consumed while it operates. The vibratory-mechanical scanner, somewhat like a telephone receiver, has an almost unlimited life. It has no bearings or sliding parts. The factory cost of the former including shrinkage is about $20.00 and the latter about $4.00.

The amplifier for the cathode-ray tube must supply 3 high-voltage circuits with accurate waveform power, with one of the circuits drawing all the lighting energy at frequencies between the bottom of the range and say 2 megacycles. The amplifier for the mechanical system likewise has 3 circuits, but only one of these must be of high fidelity over a broad band and that one is of medium output and voltage. The other two circuits are very low voltage and can be of any waveform. I would roughly estimate the cathode-ray system amplifier at about 3 times the cost of the amplifier for the vibratory-mechanical system. In addition to this equipment the mechanical system requires a source of light, a Kerr cell and a screen. These items should cost about $10.

To sum up, the retail selling price of a cathode-ray receiver for a small picture, that is to say 6 x 8 ins. would be about $250. The retail selling price for a mechanical system receiver producing a 3 x 3 ft. picture would be about $200.

GENERAL

In the technical and commercial race between the two systems, the mechanical has the distinct advantages of picture size and cost. But what of the fragility of the big and expensive cathode-ray tube, and the danger of bringing high-voltage circuits in the home where busy little mischievous hands may cause tragedy? (This possibility is minimised in commercial practice by incorporating switches that automatically disconnect all high voltages whenever the doors to their houses are opened.—Editor.) The cathode-ray television system is a monumental achievement, created from the contributions of numerous talented engineers and inventors with the expenditure of many millions of dollars. But in my opinion, although it is a rare technical success it is not a commercial answer to the problem, but more accurately a bridge from the pioneer Nipkow rotors to the vibratory-mechanical scanner.

Looking ahead, I expect commercial television in the home in color. Can the cathode-ray system look forward with confidence to the development of a picture in color with commercial home apparatus? (See “Color Television with Cathode-Ray Tubes”, pg. 105, in the article by Allen B. Dumont that appeared in the August 1936, Television Number of Radio-Craft.—Editor.) The mechanical scanner can do the job with the use of 2 carriers and a single scanner!