RADIO FACSIMILE

An Assemblage of Papers from Engineers of the RCA Laboratories Relating to the Radio Transmission and Recorded Reception of Permanent Images

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TAPE FACSIMILE: HISTORICAL AND DESCRIPTIVE NOTE

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Introduction

TAPE facsimile, as a new and distinct method of communication, originated as an off-shoot of the early work on broadcast facsimile. Its possibility became apparent when experiments were being conducted with carbon paper facsimile recorders which operated continuously with a roll feed. The ordinary 8½-inch wide strip was reduced to a fraction of an inch, and the pitch of the recorder helix from 9 inches to ¼ inch. This allowed space for one line of type along the tape, and, at the same time, a corresponding increase of helix drum speed. As a result the strip was fed out rapidly, and as many words were recorded per minute as with the original page system. The scheme seemed attractive for message communication.

Historical

The first such equipment was assembled in 1931 and was put through a series of tests and demonstrations. The apparatus was in three parts, a typewriter rebuilt to print on strip instead of on a page, a scanner, and a recorder; each with the necessary amplifiers. The original scanner operated on the same principle as the early television devices, using a disc about 4 inches in diameter with a circular row of holes near its periphery. These openings were brilliantly illuminated and their image was focussed through a projection lens and prism on the tape. As the disc rotated the light spots followed one another across the ½-inch tape at a rate of 30 per second. Meanwhile the tape moved forward at a rate to give 60 scanning lines per linear inch. The reflected light from the paper was collected by a phototube, and thus facsimile impulses were obtained and amplified in the usual way. The recorder followed closely the principles already used in the broadcast facsimile receiver, except for the reduction in scale of the helix drum. Also, a typewriter ribbon was substituted for the carbon paper. Fair results were obtained with this apparatus. By using series motors and alternators special tests were made at speeds up to 120 inches per minute, which is equal to about 200 words per minute of typewriting.

In most of this work both scanner and recorder were driven by synchronous 60-cycle motors. It was apparent at once, however, that much leeway could be allowed in the speed control if a two-turn helix were used. This would give two copies of the line of type, one above the other; and as one line drifted off at the bottom of the tape the other would come in at the top. Thus there would always be complete readable words in one line or the other. This method has been described elsewhere in detail.[1]

Scanning Methods

The next step was the reduction of the apparatus to simpler and more compact form. One of the most interesting improvements was an optical system for the scanner which obtained the scanning action by means of a rotating hexagonal prism. This device proved to be very satisfactory and is being used in present equipment. It is outlined diagrammatically in Figure 1, both an elevation and a top view being given to show clearly the position of the cylindrical lenses. Proceeding from the exciter lamp toward the phototube, the first lens is a spherical condenser and focusses the image of the filament on the last cylindrical lens just before the tape. Next comes a vertical slit diaphragm. The first cylindrical lens tends to focus the opening of this diaphragm to a vertical line of light at the tape, but this line is collapsed to a point by the second small cylindrical lens near the tape. Interposed between the cylindrical lenses is a hexagonal prism, mounted on a vertical shaft. It is rotated by gearing from a synchronous motor, once around for every six scanning lines. As indicated by the dotted line in the top view, the light is refracted so that the spot moves across the tape as each face of the prism turns across the beam. At the corner between faces the spot jumps back to its starting position and repeats the motion. The other component of the scanning is

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[1] Shore and Whitaker—"Tape Facsimile Synchronizing Systems," pp. 270-283.

obtained by moving the tape forward at a constant speed such as to give about 90 lines per inch. The size of the spot at the paper is about 0.010 inch square. Obviously spherical lenses could be used throughout, but greater light efficiency is obtained

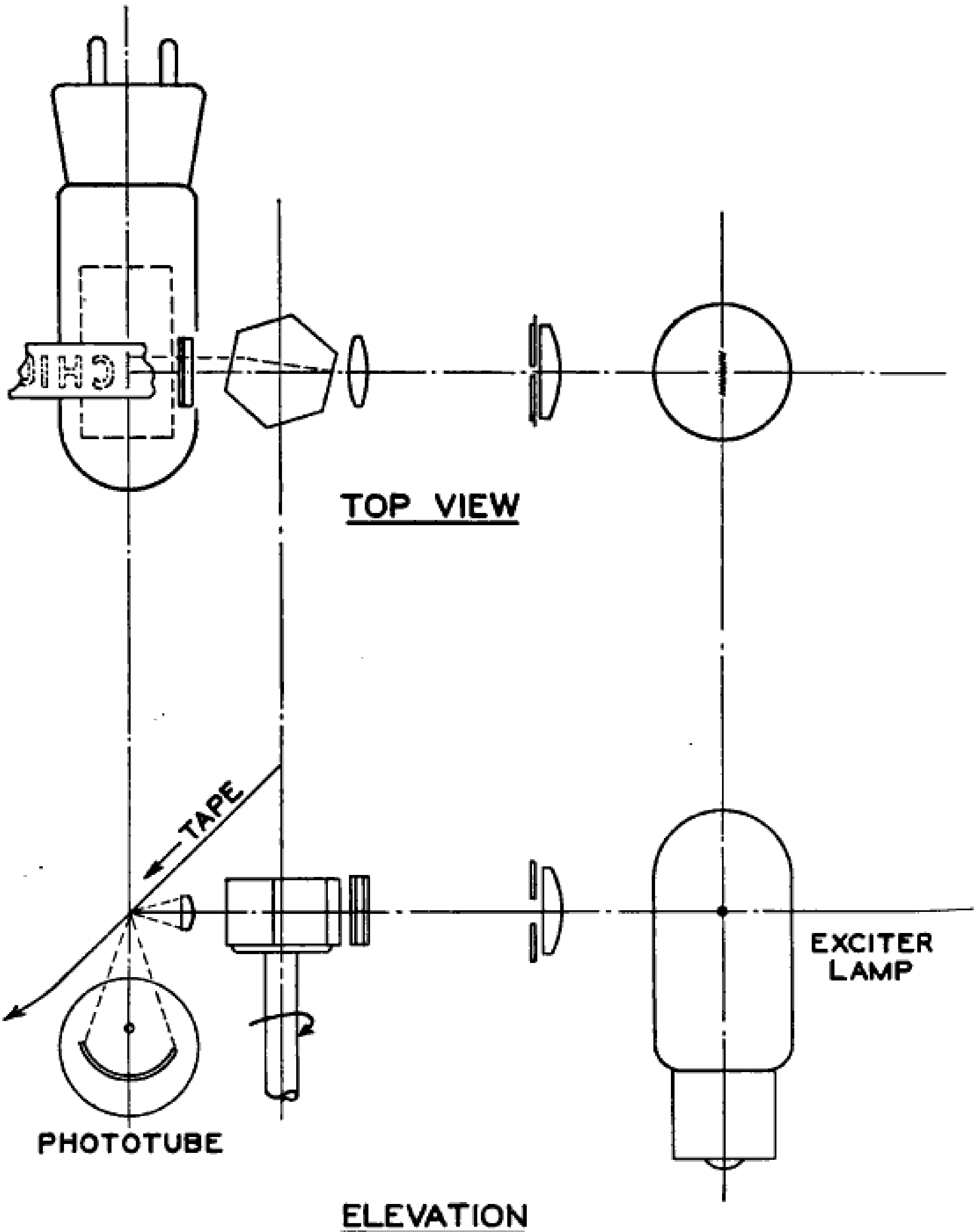

Fig. 1.

by the system here shown. The amount of light received by the phototube is also increased by placing it on the line of direct reflection from the paper. This is undesirable in page scanning, but is permissible here because the original copy is always written or typed, and the black areas are dull surfaced.

The circuits for amplifying the picture signals generated by the phototube are similar to those used for page facsimile and will not be described here. The one difference worth noting is that the frequency characteristic need not necessarily extend to zero, because the speeds are about 60 strokes per second and the copy always consists of black letters covering a small part of the total white area scanned.

The mechanical requirements on a tape scanner are basically very simple. If the scanning speed is 60 strokes per second, for example, the prism is rotated by a suitable reduction gear from a synchronous motor at 600 r.p.m. Further reduction gearing turns a tape feed roller. These parts are arranged with the optical system and amplifiers in whatever form is convenient to give the desired operating procedures.

TAPE RECORDERS

The first recorder was built with a helix about $\frac{5}{16}$ inch in diameter, a short printer bar, and means for feeding a white and a carbon paper strip between them. Present designs use the same method. The printer bar is actuated by a magnetic driver unit supplied with picture impulses from a suitable amplifier.

Many methods of printing on the tape were investigated. Carbon paper and typewriter ribbon are about equally good; the paper is run through once and either wound up or discarded into a basket, while the ribbon is provided with an automatically reversible feed. A tape of colored paper with a white wax coating, known as "Stylograph", gives good copy, but soon gums the mechanism with the scrapings from its surface. The most successful method found is to use a plain white paper tape and to ride a soft surface inking roller against the recorder helix on the side opposite the paper. This inking roller is dampened in turn from a felt roller impregnated with a quick drying ink. Thus the raised surface of the helix is constantly coated with ink, which is transferred to the paper under pressure of the printer bar.

Like the scanner, the mechanical construction of the recorder is very simple. The helix can be placed on an extension of the motor shaft and a paper feed roller is driven by additional reduction gearing. One form of portable tape recorder is shown in Figure 2. Here the box contains the motor, the printer amplifier, and the reel of white tape. The helix drum can be seen in the center and above it the case for the inking rollers. This particular unit was designed to operate on a 12-volt d-c power supply.

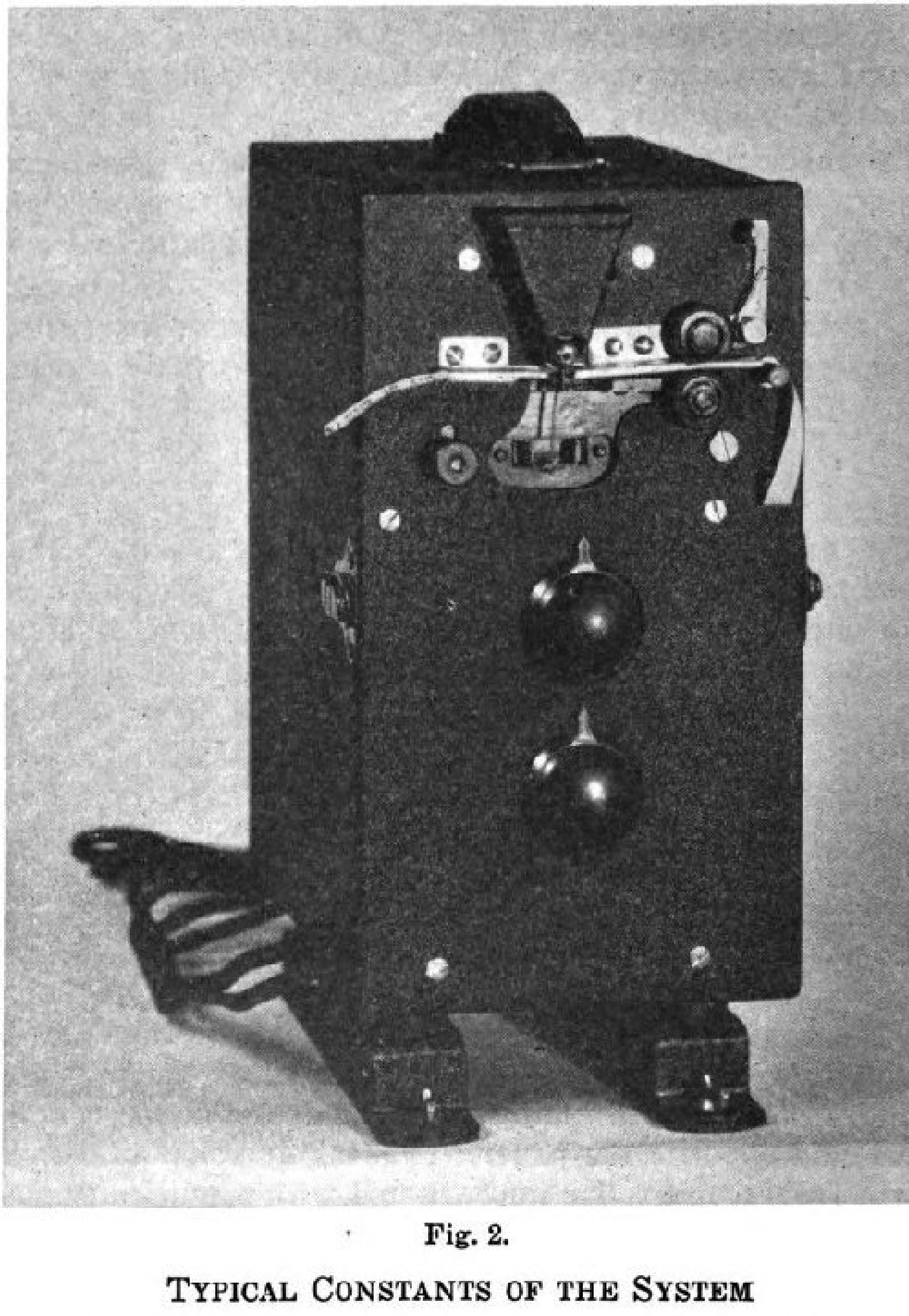

Fig. 2.

TYPICAL CONSTANTS OF THE SYSTEM

One set of design constants for a tape facsimile system are tabulated below. These are typical in the sense that they give satisfactory operating speeds and can be easily realized in a practical apparatus design. They do not necessarily correspond with the values which have been used in the various programs of investigation.

Number of scanning strokes per second...	60
Total length of stroke..................	0.250 inch
Lines per inch of tape..................	90
Facsimile Index, $90 \times 0.250 =$	22.5
Width of tape...........................	0.375 inch
Height of letters in type line............	0.125 inch
Speed of tape...........................	40 inches per minute
Words per minute (approx.)...........	60

Based on the above figures it is seen that the linear speed of the scanning spot is 15 inches per second. The maximum impulse or keying frequency required can be determined if the required number of picture elements per stroke are known. For upper-case typewritten letters as used in communication service, adequate definition is provided with 16 elements per stroke, or about 10 elements in the height of a letter. This gives 8 cycles per stroke or a keying frequency of 480 cycles per second. This makes no allowance for upper harmonics to give "square" dots, as it has been found in practical applications that sufficiently clear letter formation is obtained with impulses of sine wave shape.

In normal transmission a subcarrier is modulated by these impulses, and in turn modulates a telephone transmitter. However, direct cw keying of the radio carrier can be employed instead. The relative merits of the two systems have been discussed elsewhere.[2]

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[2] Whitaker and Collings—"Practical Applications of Tape Facsimile Systems," pp. 284-293.