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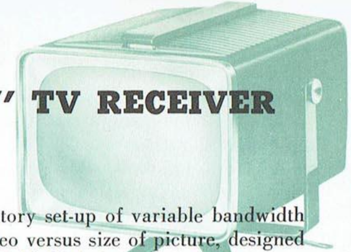
# DEVELOPMENT OF THE RCA "PERSONAL" TV RECEIVER



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**PROLOGUE**—In looking back, the engineering of the Personal TV presents an interesting paradox, which taught us much. We should like to pass this on for whatever benefit other engineers might receive from it.

Our case in point . . . Regression in receiver picture size, in itself, is not difficult for the development or design engineer to accept; but the consequent compacting of a receiver design to the extreme appears, in many ways, to conflict with the evolutionary and currently accepted "axioms of prior art" to which the design engineer is dedicated. The development engineer, while respecting the **cans** and **cannots** of a prior art, is also aware that under their influence he can become addicted to "prior artistry" himself. The Portable TV is quite a departure from currently accepted "state of the art" trends. By compromising in the middle ground of both design and development thinking, a yielding, conservative approach was taken in working within the severe package dimensions and established performance characteristics. The resulting product successfully brings together past experience and a new concept.

It is a credit to the members of the engineering team who worked on the Personal TV design, who realized the problem existed, considered it objectively and used the problem to harmonize their effort, rather than hinder it.

The RCA Eight-Inch "Personal" is believed to be the smallest and the most compact television receiver on the market today. It is the embodiment of a circuit economy in TV design that has never been approached heretofore.

Intended, at the time of its inception, to utilize only 12 tubes, as compared to the 19 tubes plus a crystal of the smallest (at the time) RCA 17-inch receiver, the "Personal" wound up, finally, with 11 tubes, four crystals, and a selenium doubler (the equivalent of 14 tubes) in a package of approximately 1/5 of the 17-inch set in volume, and performance and sensitivity quite comparable to the 17-inch set from the standpoint of normal utility.

The small portable was a challenge from the time it was conceived in a skeletal form. Could high performance be obtained in the small dimensions desired? If so would the Public accept it? After careful study, a prototype was presented to top management, and the project was given their blessing. The continued encouragement and guidance of Engineering management played a very important part in carrying it through to successful completion.

Some conflicting opinions arose in the early design stages of the Personal TV. The smallest RCA receiver at the time, a 17-inch set, represented the minimum standard of performance that was considered to be acceptable. A picture smaller than 17 inches was believed to be a thing of the past; picture brightness lower than that afforded by a minimum of 12 or 13 kilovolts, a resolution below 300 lines, or sound output appreciably less than a watt were considered to be out of the question. The consensus, both within the Company and in the Industry, was that little could be done to advance the state of the art except through small evolutionary changes, on which the Industry had been working very hard right along.

Against this consensus, the Product Development activity of Black and White Television Engineering advanced a supposition that the "Big Boss", the Public, might have a different view. That, having conceded some minor reductions in performance of radios in return for reduction in size, cost, and weight, the Public was ready for a similar step in TV: that a compact, light-weight, and relatively inexpensive package, for use at shorter viewing range than the larger sets, and therefore with correspondingly smaller picture and lower sound volume, could be successfully introduced.

### EARLY INVESTIGATIONS

Evaluations and demonstrations of the above points were started with a laboratory set-up of variable bandwidth video versus size of picture, designed by B. E. Nicholson, and of a very narrow, but very high-gain single-stage i-f amplifier by D. A. Comninos. These demonstrations proved quite conclusively that reduced bandwidth on a reduced-size picture meant a loss of only some finer detail, but not of the apparent overall sharpness; provided the overall "square-wave" response was corrected by adequate peaking of the higher video frequencies, and was free of any "smear."

An examination of this picture revealed a certain objectionable behaviour of phase response with adjustment of the fine tuning control. As a result of this analysis, corrective measures were instituted through partial staggering of the i-f circuit responses. When demonstrated to management, the pictures were concluded to be thoroughly satisfactory for commercial usage; particularly in view of the fact that all important transmitted information is generally carried by the lower-frequency end of the video spectrum and that some picture degradation due to loss of high frequencies is not objectionable on the 8-inch screen.

Fig. 1 illustrates the greater importance of adequate peaking and "square-wave" response over that of bandwidth response on the apparent sharpness of the picture.

There were two factors that finally determined the size of the "Personal": (1) the width of the smallest available tuner, which had to be nested beside the kinescope neck, and (2) the qualitative evaluation by management of the picture and package as a whole. The choice of the 8-inch kinescope as the smallest practicable size proved to be a wise one, for even with the small number of tubes and components, this minimum package has little room to spare.

### THE CHALLENGE OF CIRCUIT LAYOUT

The various aspects of physical development of the chassis in locating the various functional groups of components were that they should be located: (1) in the most logical positions that the space would permit; (2) in such positions that the heat generated and radiated by some would not be harmful to others, and so that the ventilation in the cabinet would have the greatest cooling effect; (3) in such positions that the effects of the high-power stages, such as the horizontal deflection, on points of high sensitivity, such as the picture detector, could be made negligible, and (4) in such positions as would allow greatest ease of manufacturing, and of serviceability in the field.

### KINESCOPE DEVELOPMENT

Since the largest single component was the picture tube itself, it was essential that its contours be designed to provide maximum conservation of space without materially adding to necessary circuitry. This was achieved through the cooperation of Mr. C. W. Thierfelder, Manager of Black and White Kinescope Design at the Tube Division in Marion, Indiana, and whose efforts in every phase of development of the 8-inch kinescope have produced a picture tube of excellent quality and value.

Because the non-aluminized kinescope was used in the final design, a higher ultor voltage was required. This higher ultor voltage was somewhat greater than the value which would have been most economical to utilize.

### DEFLECTION PROBLEMS

The problems of horizontal and vertical deflection and high voltage were assigned to H. D. Twitchell, Jr., who first started along the lines of sinusoidal scan, demonstrated by C. M. Hunt of Product Design a few years before. Mr. Hunt had shown that by blanking every other trace of the sinusoidal scan, and discarding the crowded edges, it was possible to obtain a usable picture on a wide-angle tube. But as quality requirements for the "Personal" were raised, it became apparent that standard circuitry would have to be used.

Proceeding along conventional lines, Mr. Twitchell evolved a horizontal deflection transformer and circuit layout that are unique in compactness and shape, to fit the limiting clearances around the bell of the kinescope. Since the +B and filament power consumption of the deflection section of a receiver is generally between 1/3 and 1/2 of total, the over-all heat problem of the "Personal" demanded the utmost in power economy, particularly in the horizontal deflection stage. Space limitations and the relatively short arcing distances required extensive overvoltage and altitude chamber tests to insure adequate margins of safety. H. D. Twitchell is shown in Fig. 2, with H. A. Bond, technician, who assisted in preparation of the high voltage transformer samples and did the wiring of most of the "front" chassis units.

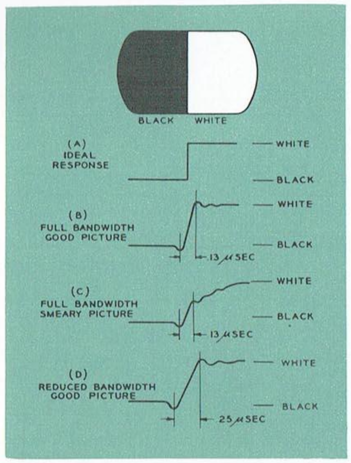



Fig. 1—Illustration of "edge sharpness" of picture detail as a function of receiver square wave response. (a) shows infinite rise time in black to white transition; (b) indicates a rise time close to system capabilities; (c) shows poor rise time due to inadequate high-peaking—transition depends on low frequency response, creating smear; (d) indicates linear transition from black to white (good picture) but with less detail due to longer rise time.

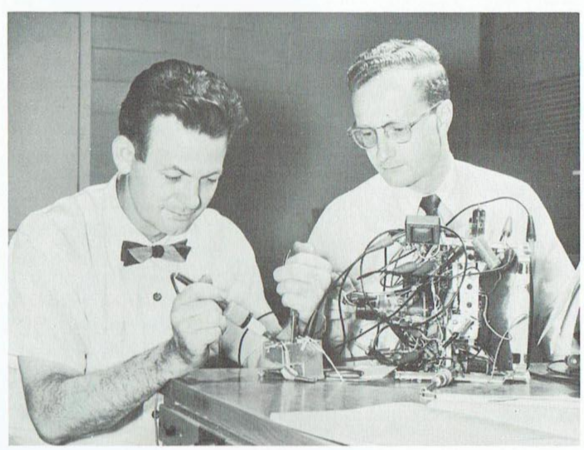
### RADICAL SOUND CHANNEL DEVELOPED

Development of what is believed to be the most economical sound channel in any commercial TV receiver was carried out by E. B. Smith (Fig. 3). In spite of space, voltage, and power limitations, he obtained the needed sensitivity and quality using a single dual-function tube and three crystals, and by reflexing the low-level audio through the 4.5 megacycle i-f pentode. This reflexing, or re-using of the 4.5 megacycle amplifier a second time, for audio, brought in some new problems. Intermittent "Holes" in the carrier envelope were caused by excessive plate swing with pulses of audio in series with the tuned circuit. The "Outer grid effect" (electrons returned to the #1 grid region by the negative excursion of the outer-grid, i.e., plate, in this case) also occurred, aggravated by the combination of low plate voltage and high plate impedance, which was needed for the sake of sensitivity. Teaming up with Mr. Comninos, who handled the development of the picture i-f and the second detector, he established the criteria for adequate sound sensitivity without interference of sound with the picture.

### I-F PERFORMANCE

A "Sound bump" circuit was added by Mr. Comninos in the first i-f stage, to peak up the sound carrier and to provide additional gain. A boost in sound gain was required because the narrow over-all band width, necessary to achieve the sensitivity for the picture, allowed less gain for

Fig. 2 — H. D. Twitchell (right) and H. A. Bond making wiring changes in the high voltage transformer in a developmental set-up.



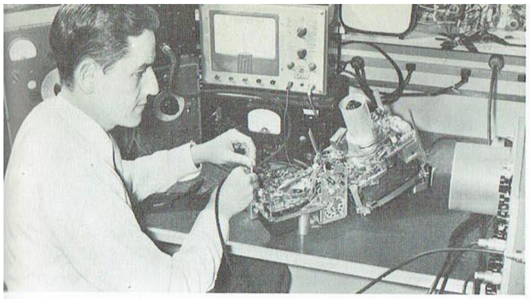


Fig. 3a—E. B. Smith conducting response tests on the ratio detector.

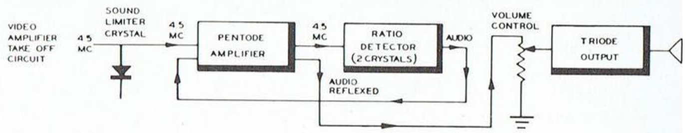



Fig. 3b—Block diagram of the sound reflex amplifier.

the sound i-f carrier. The cost of the "bump" circuit was small compared to that of the full stage that would have been needed for a similar result. The overall i-f curve (composite of the converter, the first i-f on the tuner, and the second i-f on the chassis) is a rather sharply pointed "haystack", and it required extensive studies of a number of possible alignment techniques, with a view of obtaining maximum sensitivity on weak signals, yet allowing maximum shift and widening of the curve as the AGC bias is increased. D. A. Comninos, who handled all these problems, is shown in Fig. 4 checking the overall alignment of a production unit.

#### R-F PERFORMANCE

The problems of r-f performance were assigned to G. E. Skorup. In a series of carefully planned comparative tests of various types of tuner arrangements, he proved out the advantages of the one proposed by J. C. Achenbach's Tuner group, and was quite instrumental in its final adoption. In its application to the chassis, as well as modifications of the input circuit and filters, extensive coordination between Mr. Skorup and L. A. Horowitz and R. Barone of the Tuner group was required. Mr. Skorup also contributed to the development of the raster centering attachment and mounting, and of the beam bender and its adjustment. The latter was made difficult by the shielding enclosure of the kinescope neck. Fig. 5 shows Mr. Skorup measuring light output versus adjustment of the beam bender.

#### OVERALL PERFORMANCE AND DESIGN

The overall operation of the receiver, as well as the "square-wave" response, synchronization, and stability of the picture were handled by B. E. Nicholson. Overall receiver operation included the problems of heat, both of the components and the cabinet, and of electrical interferences between functional sections. The compactness of the chassis, and the proximity of high-power deflection circuits to picture detector required the use of a shield over the yoke; the proximity of the power transformer to the kinescope neck required the use of a shield over the neck. The temperature rise of the power transformer, the effect of its heat, and of heat from the deflection tubes on the walls of the cabinet, and the shape and size of ventilation louvers, all required extensive heat runs. Some rearrangement of components was necessary before satisfactory results were finally obtained. In these heat runs he was assisted by R. A. Bowen, technician, who also wired the "rear" chassis, assembled the complete chassis and instrument, and collected the wiring information. Fig. 6 shows Messrs. Nicholson and Bowen with one of the developmental chassis in an unfolded position, examining a problem in wiring.

#### MECHANICAL DESIGN

E. C. Lick, Mechanical Engineer, was assigned to the mechanical design of the overall instrument, including the chassis and the cabinet. Ably assisted by R. A. Norman, also of the Mechanical Design group, and by J. D. Luber and F. G. Schobel, of Drafting, he faced the very difficult task of meeting the spacing requirements for a number of electrical components in the chassis design, which resulted in a three-level "front" base. The cabinet styling requirements were solved to include a very special shape of louver to ventilate the chassis. The "rabbit-ear" antenna also presented serious problems, particularly of electrical contact between several sets of parts. The interlocking of the power lead-in between the cabinet and the chassis proved to be a problem point because of safety margins required under limited space conditions. The excellence of the solutions to these problems is a credit to the mechanical design team who solved them.

#### FIELD TESTS

Field tests of the circuits in various stages of development were conducted in a number of locations under various conditions of reception. Evaluation of picture and sound quality, of overload and cross-modulation

**SIMEON I. TOURSHOU** received his B.S. in E.E. from Robert College, Istanbul, Turkey, in 1928, and his M.S. in E.E. from Michigan College of Mining and Technology in 1930. His experience covers, in main, seven years with Philco and nearly eighteen with RCA. The latter includes development of the second "Personal" radio, the BP-12, development and design work on pulse altimeters and airborne radar, and on television.

In the Black and White TV Engineering, he is the Manager of Product Development group which has been responsible for a number of RCA and industry "firsts," such as the receivers with metal kinescopes, receivers with "wide angle" deflection, 21-inch receivers, receivers with 90° deflection, as well as many deluxe, top of the line models. The group spearheads the continuous search for better and cheaper circuits, techniques and products.

characteristics, of sensitivity, selectivity, noise immunity, airplane flutter, and of the effects of various alignment procedures, and combinations of video peaking on the sharpness of the pictures obtained from various transmitters, was almost a continuous process. Facilites of the RCA Service Company's Browns Mills Laboratory, strategically located as "semi-fringe" for a large number of stations, were used again and again. The assistance of E. A. Hilderbrand and W. G. Manwiller, RCA Service Company Quality Control, and their wide experience in field testing were valuable contributions.

Among other types of tests, particularly exacting were those required by the Underwriters' Laboratories, (see J. W. Fulmer's article in Vol. 1, No. 3, RCA ENGINEER), and in these the guidance of Mr. Fulmer, of the Engineering Services, played a most decisive role. The assistance and guidance of F. B. Stone, the tube coordinator for TV Division, in various problems of tube and crystal application have also been invaluable.

The work of L. T. Fowler and his Components group, particularly of A. C. Thompson and K. G. Weaber, in obtaining and maintaining the uniformly high quality in the new and physically smaller components has been responsible for the relative freedom from trouble in the factory, as also were the efforts of J. M. Wright and his Resident Engineering group in Bloomington, and particularly C. J. Blume in piloting the factory into smooth and uniform production.

In conclusion, the RCA Personal TV presents a relatively new concept in television home viewing. It is the first set on the market to provide true portability and small-set convenience, modestly priced for the "second-set" market. The teamwork that developed in the design engineering phases helped promote a greater understanding between the members of the Produce Development group and between this group and others who contributed their specialized knowledge to the project.

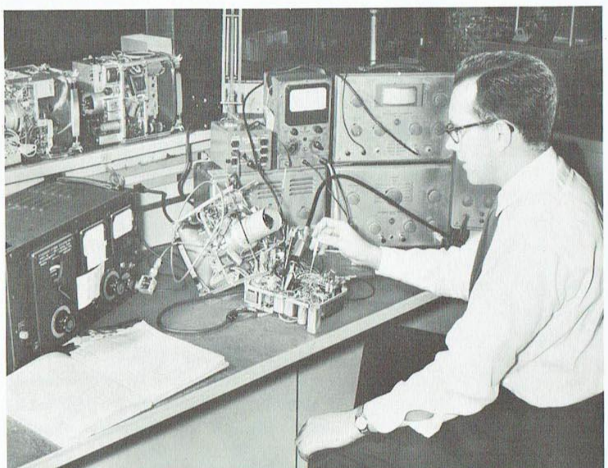


Fig. 4—D. A. Comninos checking overall receiver alignment. Particular care was taken in this phase of design to provide a convenient alignment procedure.

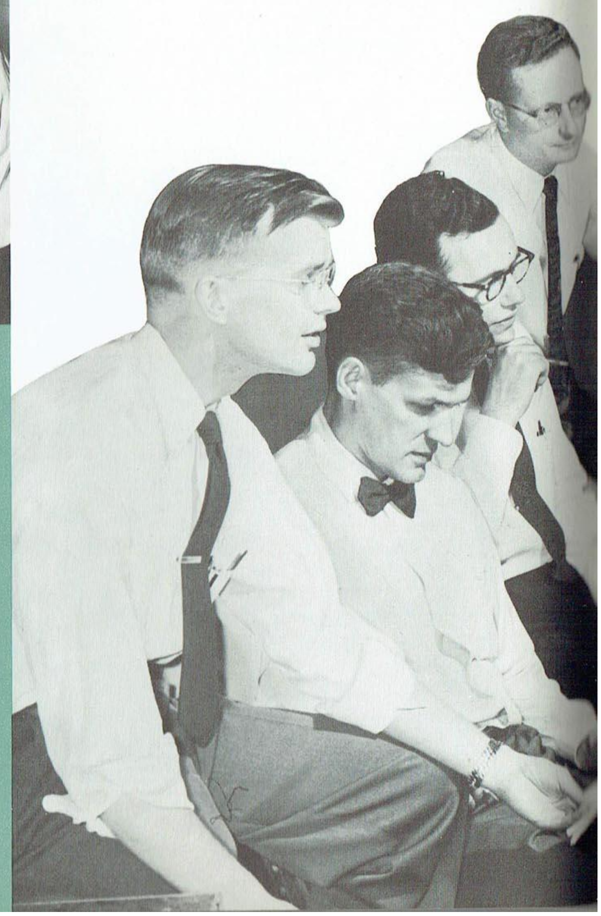


Fig. 7—Group meeting of Product Development, discussing the final design of the Personal TV. Left to right: B. E. Nicholson, R. A. Bowen, D. A. Comninos, H. D. Twitchell, Jr., G. E. Skorup, E. C. Lick, H. A. Bond, F. G. Shobel, J. D. Luber, S. I. Tourshou, Mgr., and E. B. Smith.

Fig. 5—G. E. Skorup measuring light output versus ion-trap magnet adjustment. Notice the special tool for adjusting the ion-trap inside the kinescope neck shield.

Fig. 6—B. E. Nicholson (left) and R. A. Bowen examining an early "breadboard" version of the Personal TV. This "unfolded" set-up provided ease in accessibility to all components for test.