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EVOLUTION OF THE TELEVISION RECEIVER

INTRODUCTION

The discovery of photo-conductivity in the 19th century was a major prerequisite of modern television systems. For a long time mechanical scanning was thought feasible. Using a Nipkow disc Baird demonstrated a low definition, 30-line system of this type in the late twenties. After considerable development mechanical scanning reached the limit of its performance with a 240-line system in 1936.

When it was accepted that mechanical scanning with 240 lines, or possibly a little higher, could not provide the required high definition, development of an all-electronic system received a much needed impetus.

Television as it is known today can be considered to have arrived with the invention of the photo-storage camera pick-up tube and the use of a cathode-ray tube as the display device.

In the mid 1930's extensive and rapid development of the electronic television system took place culminating in 1936 with the introduction of the world's first regular television service broadcast by the BBC transmitting 405-line high-definition pictures, a system still in use today.

Initially television receivers were bulky when compared with modern designs and consisted of several separate chassis accommodating vision and sound i.f channels, horizontal and vertical time bases, power supplies, a long necked cathode-ray tube and loudspeaker. Because of the multiplicity of units and ancillary items most receivers were of the console type.

A large number of valves were required and,

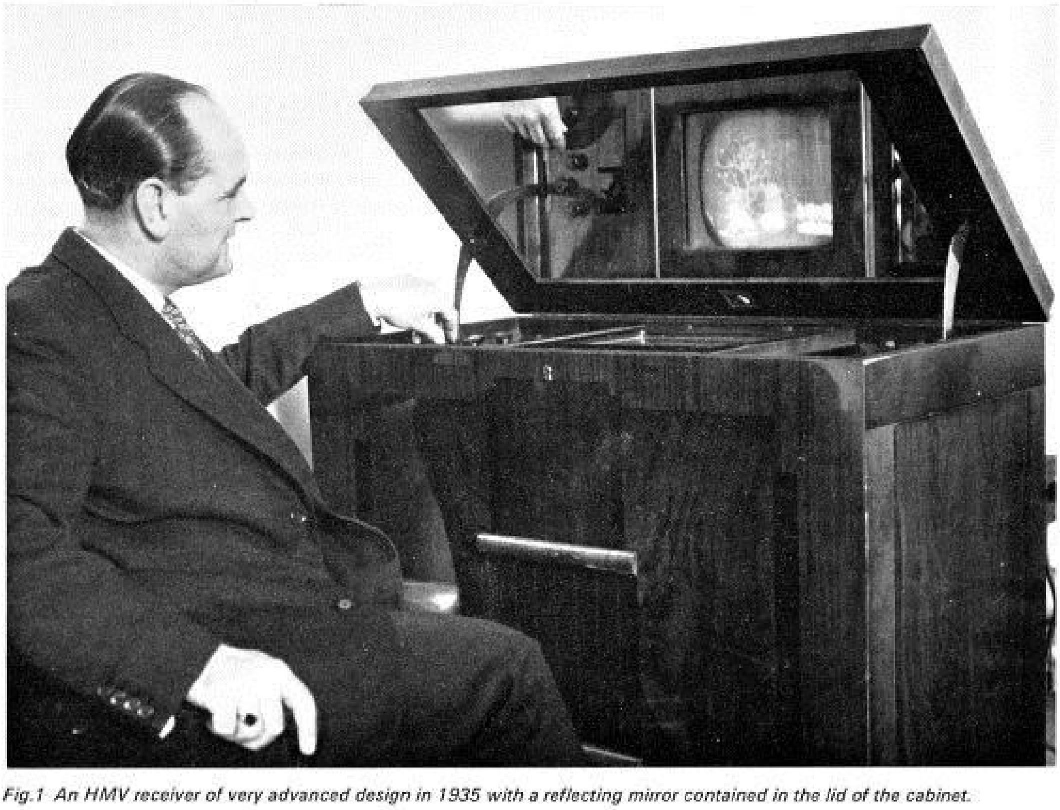


Fig.1 An HMV receiver of very advanced design in 1935 with a reflecting mirror contained in the lid of the cabinet.

owing to the lack of valves designed for vision use, valves intended for domestic sound receivers and even low-power transmitters were used.

The cathode-ray tubes were of the electrostatic deflection type, and of small diameter.

The e.h.t supply was obtained by stepping up and rectifying 50Hz mains. This required an expensive transformer together with relatively high value capacitors in the filter circuit which stored a considerable charge. The power pack was quite rightly treated with respect because of the almost lethal hazard should an accidental discharge occur.

As the cathode-ray tube had a small deflection angle and a particularly long neck, in order to reduce the cabinet depth to an acceptable size some designers mounted the tube vertically with the picture viewed through a 45° mirror fixed to the lid of the cabinet.

Although the first generation of receivers used either tuned radio-frequency or superheterodyne circuits the trend was clearly towards the use of the superheterodyne – the modern accepted standard.

Gas filled valves had also been adopted for use in the vertical and horizontal times bases.

These early receivers also incorporated a 'System Switch' for the selection of either the 405-line 50 frame Marconi/EMI system or the Baird 240-line 25 frame mechanically scanned system. This enabled the electronic and mechanical systems to be compared. However, in 1937 the BBC discontinued the use of the Baird system.

This stage of high definition television remained basically unchanged until the outbreak of war in 1939 when transmissions ceased.

In view of the large numbers of receivers in private hands it was decided, when transmissions resumed, to continue with the 405-line 50 frame standard and to leave the question of even higher definition until a later date.

With greater receiver sensitivity the effective service area of the London station was considerably extended and television quickly captured the popular imagination. The television receiver was no longer an item of curiosity or a status symbol but a relatively simple and dependable piece of equipment.

MAJOR CIRCUIT AND COMPONENT DEVELOPMENT

One of the most outstanding circuit developments was the generation of the e.h.t voltage by means of the horizontal flyback pulse. This circuitry dispensed with the high voltage 50Hz transformer and associated filtering. Thus was made possible the a.c/d.c technique in which the valve heaters in the receiver were all connected in series.

In 1950 a range of valves with 300mA heaters were introduced. The slope of some of these valves was 7mA/V as compared with 3·5mA/V previously, and later, with frame grid valves, a slope of 20mA/V was obtained.

As a result whilst five i.f stages were originally needed this was reduced to two and the overall number of valves reduced from 23 to 13 or so.

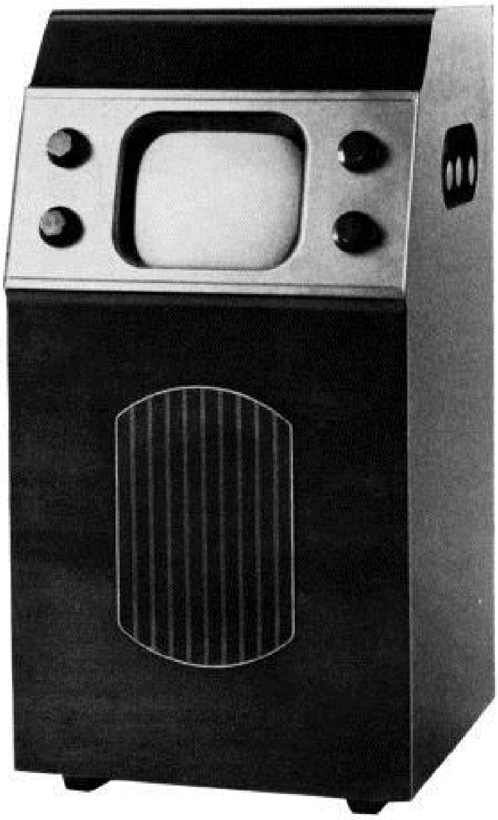


Fig.2 The Murphy A56V, a console receiver produced in 1938.

Additionally the transformer generated e.h.t was 4kV to 5kV while the flyback system produced 20kV.

In 1949 synthetic ferrites were introduced into the television industry and these materials were mainly used as cores in horizontal transformers and yokes in the deflection systems. This material has excellent properties for frequencies encountered in a horizontal deflection system and it was thus possible to reduce losses and increase the e.h.t generated in such circuits. It is now difficult to imagine television sets without ferrites.

The cost of a popular television receiver in the early 1950s was between £60–£70 so it is interesting to note this cost still prevails today despite significant improvements in performance and facilities such as push-button programme selection.

In 1949, the Birmingham, Sutton Coldfield, transmitter started transmissions and the BBC network spread within the next three to four years throughout the country. Whilst the first receivers were only designed for receiving the London Band I transmissions the immediate postwar receivers had to be pretunable to all channels in Band I up to 67MHz. This was achieved initially with taps on coils but later with permeability tuning of individual coils (usually a combination of dust core and brass was used to cover the whole band).

In 1953 Independent Television began, and from then on all new receivers required channel selecting

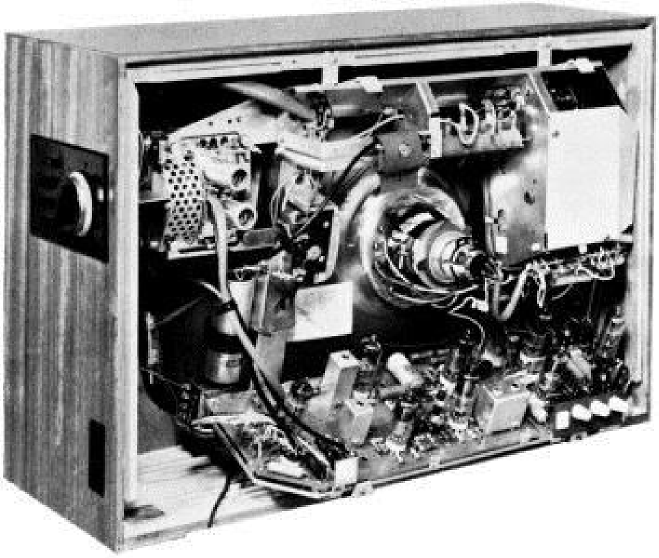


Fig.3 A 1963 single standard receiver with incremental tuner and 110° cathode-ray tube.

devices, as in each areas two programmes became available.

A variety of tuners were developed; perhaps the most common being the so called 'turret tuner' where every channel used a separate set of coils mounted on a rotary drum. Other tuners worked on the so called incremental principle where for each channel selected increments of inductance were switched in.

Such tuners usually had two discs, one for the r.f and one for the oscillator stages. Another type was the permeability tuner where in each tuned circuit an 'Aluminium Plunger' or a 'Dust Core' altered the inductance of a tuned circuit with the frequency being preset by mechanical stops of the 'plunger' or 'core'.

The latest type of 'Electronic Tuners' use carefully matched and selected diodes, back biased, to form a variable capacity controlled by the d.c voltage applied. The frequency control is thus achieved by a d.c voltage setting with band switching accomplished by forward biased diodes acting as switches. In future most tuners will be of this type.

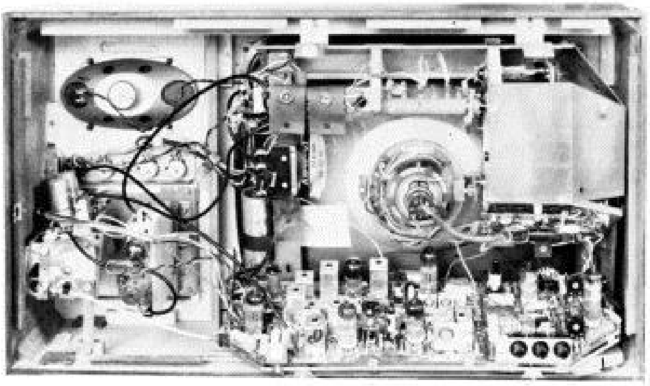


Fig.4 The receiver shown in figure 3 was converted to double standard in 1965. Included in the design are a u.h.f valved tuner, a v.h.f turret tuner and system switch mechanism.

Another significant development which changed the basic design and production approach was the introduction of printed or plated circuits. This technique was originally invented in England, taken up in America, improved, and subsequently accepted in all electronic equipment.

Printed circuits enable the manufacturer to use less skilled production personnel to assemble complex equipment uniformly. The servicing of printed and plated circuits is more difficult than that of wired circuits and the radio and television trade accepted printed circuits rather reluctantly. (G.E.C adopted plated circuits with conductors on both sides with plating also through the insertion holes for components.)

CATHODE-RAY TUBES

Development of television would not be complete without mentioning the improvements in cathode-ray tube design.

Electrostatic deflection was almost exclusively used in early receivers but the electrostatic deflection cathode-ray tube is of a complex structure with a limited deflection angle. Thus magnetic deflection soon became universal.

Initially 9in and 12in round tubes were used having a deflection angle of 50°. The first rectangular cathode-ray tube arrived in 1952 with a deflection angle of 70° and a magnetic ion trap. These tubes were magnetically focused, usually with two ferrite permanent magnets, and the glass tinted to improve daylight viewing.

The e.h.t voltage for 14in tubes was at that time approximately 12–14kV. The demand for larger tubes increased and so the scanning angle was raised from 70° to 90°. The 90° tubes were quickly improved upon and in 1959 110° tubes, with a narrow neck, were introduced.

The first generation of 110° tubes dispensed with the magnetic ion trap, had electrostatic focusing, were metal backed and operated with a voltage of up to 20kV which made possible viewing in bright daylight.

In 1964, another tube development called the 'Panorama Cathode-Ray Tube' was introduced which is intrinsically safe as far as implosion is concerned. This type of tube dispenses with the necessity of an implosion guard and thus the front to back dimensions and the weight of a receiver can be reduced.

The latest of the cathode-ray tubes, which appeared about two years ago, have squared up corners with the length and width dimensions in the ratio of 4 to 3, the usual accepted film picture standard.

A summary of materials and components evolution would not be complete without mentioning the widespread use of ceramic capacitors, both with 'Low K' and 'High K' materials, and later the appearance of plastic foil condensers such as Polystyrene, Polyester and recently Polycarbonate. All have improved characteristics and have eliminated

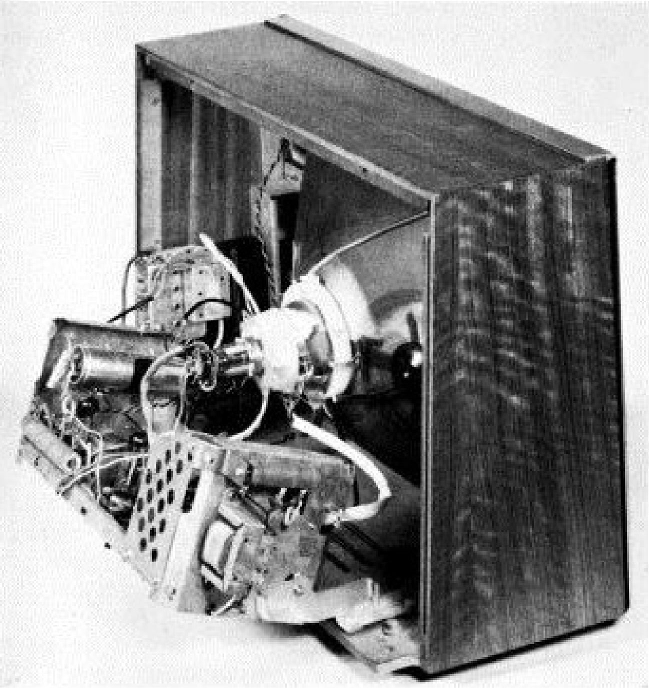


Fig.5 The latest GEC single standard chassis with u.h.f push-button tuner and 110° square cornered tubes up to 24 inches.

the wax impregnated paper condenser which used to attract dust during its lifetime and often leaked or broke down.

Transistors made a surprisingly slow appearance in television simply because the price was high initially and, apart from u.h.f tuners, offered little advantage. However, in such tuners transistors gave superior noise and gain performance and this application became universally accepted. It would be true to say that transistors appeared in quantity only with the first colour set (in the signal circuits). Only one manufacturer used transistors in all stages with the hope of increased reliability in spite of cost. But it appears that the higher reliability hoped for was not initially accomplished.

U.H.F DEVELOPMENTS

In 1956 The Television Advisory Committee was formed to decide if the 405-line system would be adequate for the next 25 years, and if there was any reason why the United Kingdom should not adopt the 625-line system for u.h.f reception in Bands IV and V. Studies were carried out and the committee published their conclusion in 1960, to the effect that the 405-line system was not adequate and that the 625-line standard should be adopted with 8MHz channel spacing, thus making improved picture quality possible. These recommendations were accepted by Government in 1962 and a new chapter started in British television receiver design and manufacture.

A u.h.f tuner had to be added for the second BBC programme and the set designed to receive both the 405-line programmes on Bands I and III and the 625-line programmes on u.h.f. Thus the Industry had to produce dual-standard sets.

The u.h.f tuner development differed to that in the United States, with British and European tuners using an r.f amplification stage preceeding the frequency changer to give improved noise and gain performance. The sets also required complex switching. In addition to selecting the appropriate tuner, the i.f bandwidth and shaping had to be altered, the demodulation diode switched to cater for positive or negative modulation, the sound demodulation switched to either a.m or f.m and the video compensation adjusted as required. Finally several circuits in the horizontal time base were switched to cater for the different line frequencies. The system switch was usually mechanically coupled to the v.h.f tuner.

When Government agreed that all programmes would be duplicated on u.h.f, the Industry began in 1969 the production of single standard 625-line sets which were simpler and cheaper than the dual standard sets.

However, until the duplication and coverage of u.h.f programmes is completed throughout the United Kingdom the dual standard set will still be produced, although in diminishing quantities.

All new monochrome and colour sets are of the single standard type offering preset push-button selection of four channels in the u.h.f band.

COLOUR DEVELOPMENT

Newton discovered that any colour could be simulated by a combination of three primary colours, red, green and blue, so it would be possible to send three complete pictures in primary colours, superimpose them, and so receive a colour reproduction.

It was also proved by the Frenchman, Valensi, in 1938, that information from a colour image could be split into a brightness and two colour components, suitably matrixed.

With this basic knowledge the American industry started to develop the NTSC Colour System. One of the most outstanding aspects of this system is that the colour information can be suitably added to a monochrome television signal, without appreciable deterioration of the monochrome picture, and so make the colour system 'compatible'.

Several suggestions for colour display devices were investigated in the early stages of colour development but so far only the Shadow Mask Colour tubes are available to the colour industry. The Shadow Mask tube is really a marvel of mass produced precision engineering embracing many technologies. A rough description would be that the three basic phosphors emitting the three primary colours are uniformly distributed in minute dots on a single screen and are simultaneously and independently excited by three electron beams associated with the appropriate primary colours.

Experimental colour transmissions on the 405-line system started in England in 1956 on a modified NTSC system using the latest Marconi colour cameras when the results achieved were quite impressive. The GEC Hirst Research Laboratory also carried out a considerable amount of work on this system. British colour television transmissions were

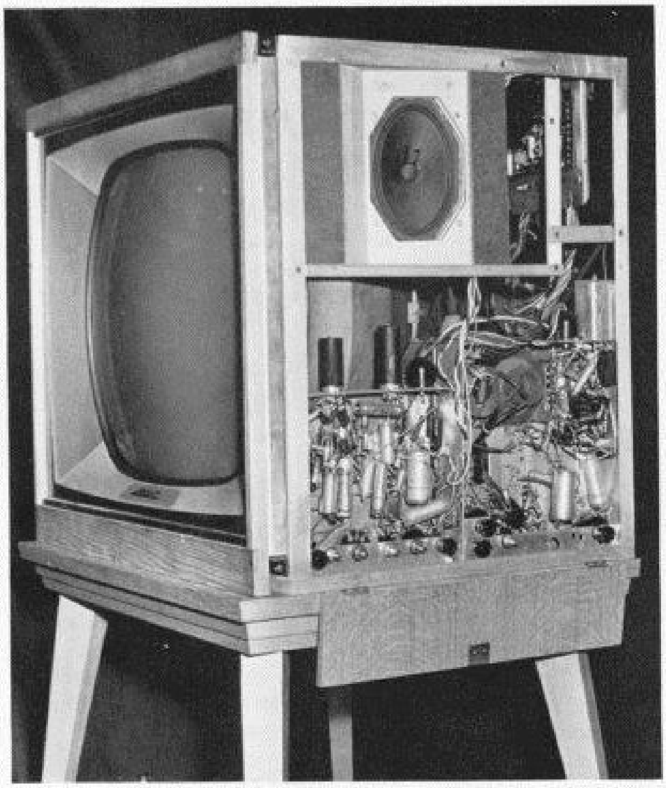


Fig.6 A 21 in. colour receiver produced in 1960.

placed on a permanent basis with the Television Advisory Committee's recommendation in December 1965, that colour transmissions should start on u.h.f 625 lines, using the PAL system. This decision was accepted by Government in March 1966. The Television Industry welcomed and supported this decision and subsequent experience proved the correctness of the choice of system.

Experimental BBC colour transmissions began in July 1967 followed on December 2nd of that year by a regular colour service. Both BBC channels now operate in colour.

At the same time the Industry commenced production of dual-standard colour receivers, capable of receiving 625 line u.h.f and 405 line v.h.f monochrome transmissions.

About this time transistors became attractive as far as performance and price were concerned. Most manufacturers, therefore, settled for the hybrid solution of the television circuit, an approach whereby all the low-voltage signal circuits were transistorized whilst high-voltage stages and scanning circuits incorporated valves. As an example, the GEC dual-standard colour receiver had eleven valves and thirty-five transistors.

Popular tube sizes were 19in and 25in, followed recently by the 22in square-cornered tube. The average cost of these receivers, excluding U.K Purchase Tax, ranges from approximately £200 to £225.

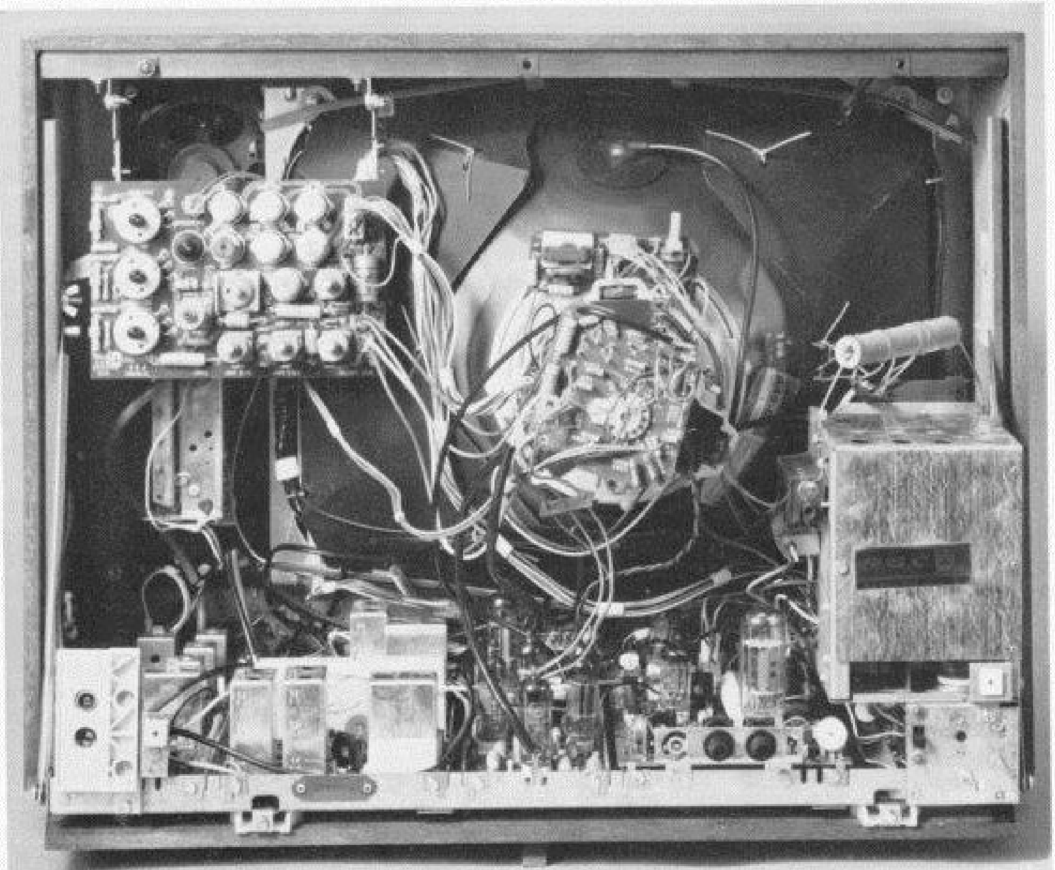


Fig.7 A compact colour receiver produced by GEC in 1969 with a 26 inch. tube.

Advances in semiconductor technology enabled some British manufacturers to include a so-called 'tripler circuit' in their e.h.t voltage supply. This circuit enabled the designer to reduce the size of a set, to improve power economy, reduce heat and eliminate the hazards of the shunt stabilizer valve (which gave trouble in some countries and did, under adverse conditions, generate x-radiation).

Subsequently, Government, together with the Broadcasting Authorities, accepted duplication of 405-line programmes on u.h.f 625 lines, thus enabling BBC-2, BBC-1 and ITA transmissions in colour to take place. This decision also enabled the Industry to commence the production of single standard television receivers, both for monochrome and colour, and similar to those used elsewhere in the world.

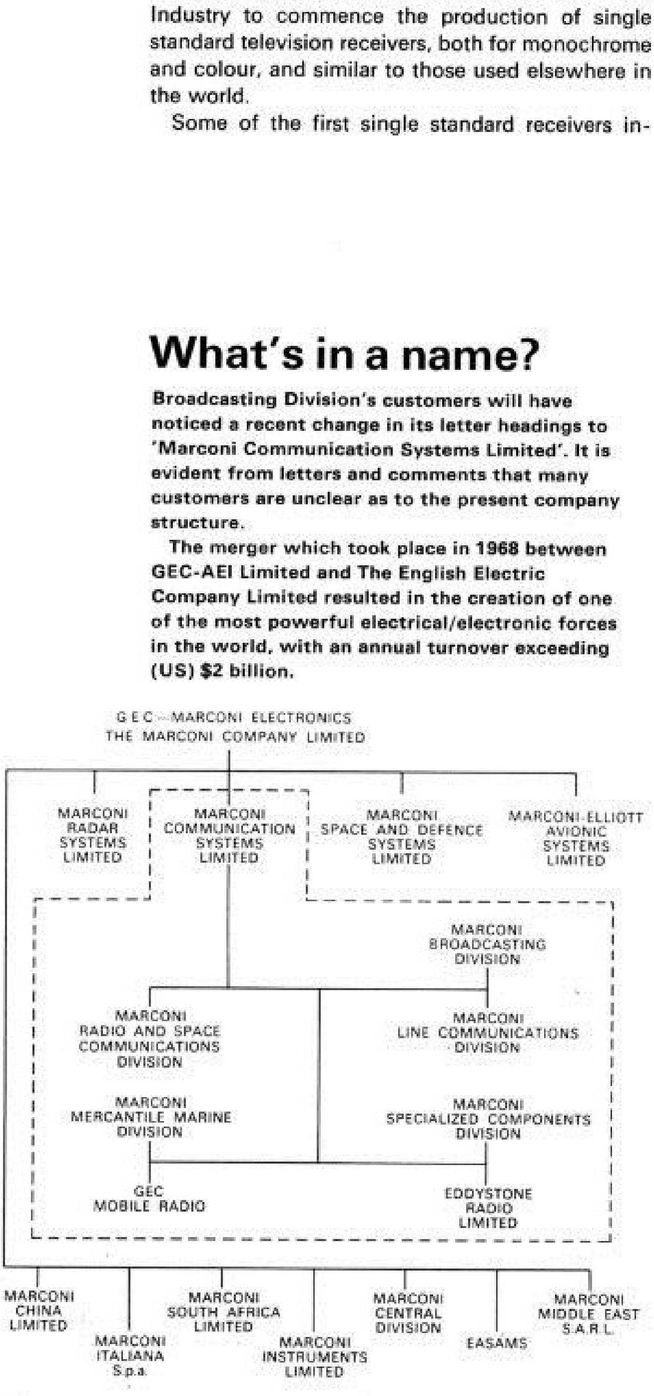
Some of the first single standard receivers incorporated not only transistors but also linear integrated circuits in the signal processing sections. Integrated circuits are devices which can replace several stages in a receiver and it is, therefore, not surprising that functions such as f.m demodulation, as well as many functions in colour decoding, can be accomplished by integrated circuits. These will in future make colour television receivers smaller, superficially simpler and, together with complete transistorization, probably, more reliable.

The history of colour television would not be complete without mentioning the analogy to black-and-white tube development and of colour tube development in respect of deflection angle. Early massed produced receivers incorporated 70° round tubes. Current receivers use 90° rectangular tubes and it is anticipated that 110° colour tubes will be used in the very near future.

What's in a name?

Broadcasting Division's customers will have noticed a recent change in its letter headings to 'Marconi Communication Systems Limited'. It is evident from letters and comments that many customers are unclear as to the present company structure.

The merger which took place in 1968 between GEC-AEI Limited and The English Electric Company Limited resulted in the creation of one of the most powerful electrical/electronic forces in the world, with an annual turnover exceeding (US) $2 billion.



As part of the restructuring which followed the merger, the electronics interests of both Companies were combined to form GEC-Marconi Electronics Limited which, with a turnover of $0·3 billion a year and employing 30,000 people, is by far Britain's largest and most comprehensive electronics organization. The composition of the Company is as follows:

The communications interests within GEC-Marconi Electronics have been brought together in Marconi Communication Systems Limited. Formed from seven well-established divisions, all of which are pre-eminent in their own field, it provides a firmly based organization with long and wide experience in communications. The Marconi Company was the first radio company in the world, and Marconi Communication Systems is the natural inheritor of its great reputation in communications. Radio communications have expanded and diversified out of all recognition since the formation of Marconi's more than 70 years ago, and the new management company reflects the present-day situation in that it can undertake every aspect of modern communications.

As its name implies, it specializes in the provision of fully working systems, and draws upon the traditional strength of the Marconi organization in systems engineering. It is fully supported by GEC-Marconi Electronics, particularly in important areas such as research, international agencies, specialized manufacture, training, spares, etc.

The divisions in the new company have been given extra strength by the combination of their diverse skills and are in a better position to tackle the total communications market, which is becoming increasingly complex, and at the same time is expanding with a rapidity which has earned the name of the communications explosion.