25 years ago, Integrated Circuits conquer radio and television

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10 years after the transistors had been introduced for radios (USA end of 1954: Regency TR-1, JAPAN 1955: Sony TR-55, EUROPE end 55: Telefunken TR1) 1966/67 saw the next technology milestone: the Integrated Circuit (IC) has been introduced in radio and television devices. A fundamental change started:

The increasing dependence to the IC manufacturers started for designers and manufacturers and with a steadily increase of the usage and spreading of ICs, these became the most important economic and technical power.

For the final consumer, the era of unprecedentedly efficient and reliable devices at lowest prices began and at the same moment, collectors of radio devices started to feel that these became increasingly difficult to repair.

All these aspects are most interesting and worth a discussion, however this contribution will be limited to the technical and chronological side of the first applications of ICs in radio and television sets.

As it was the case for the transistor radios, the USA were ahead with ICs by a nose and and the crucial contributions to the IC technology originated from the USA (Bell Lab, Fairchild, Texas Instruments, RCA among others). The Europeans (VALVO, Siemens, Telefunken and others) and the Japanese were late at that point of time.

The first use of ICs in devices of the entertainment electronics comes from television. Figure 1 shows the diagram of the audio intermediate frequency part from the 30 cm RCA Portable TV KCS 153 X, which was introduced in March 1966. The audio intermediate frequency part was selected, because integration was bringing here many advantages. A RCA IC of the type CA 3013 in silicon planar epitaxial technology is used for intermediate frequency amplification, limitation, demodulation and audio frequency preamplifier and replaces the transistors, diodes and discrete elements (i.e. resistances) otherwise necessary in discrete technology. 2 transistors, 2 diodes, 1 transducer, 14 resistances and 7 capacitors were saved.

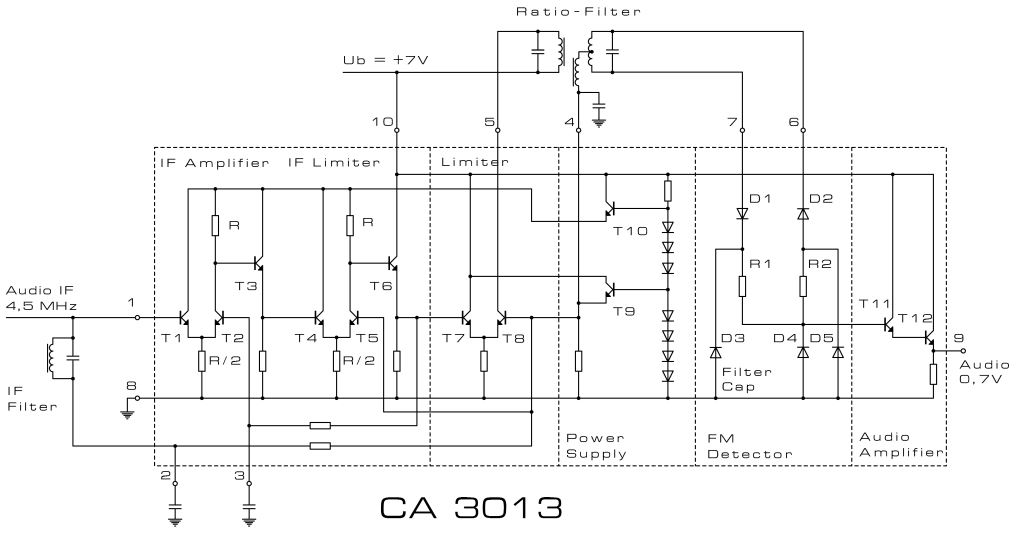

Fig. 1: Diagram of the sound IF circuit with details of the IC CA3013 of RCA in the portable TV *KCS153X*

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Intermediate frequency filters and ratio filters are usual standard elements. The circuit concept is also of usual standard. The use of the IC, because of a better limiter characteristics of the integrated amplifiers (differential amplifier stages), an improved suppression noise peaks, a high AM suppression and a wide range of the input voltage, provides an independence of the amplitude of the output signal from the amplitude of the input signal. Increased reliability and reduced space requirement of the circuit are further advantages [1], [2], [3].

The first IC radio manufactured in series (fig. 2) was introduced at the end of 1966 by General Electric Co. (GE) under the type designation P-1740 [4]. The schematics (fig. 3) of the 5-circuits AM super heterodyne shows no significant differences to usual (discrete) circuits of a transistors radio. It is possible to recognize the self-oscillating mixer stage with ferrite antenna, 3 intermediate frequency circuits with IC amplifiers, the demodulator and a two-stage audio frequency output amplifier with push-pull. An integrated 3.75 V accumulator supplies the necessary energy. It is perhaps more evident, compared to illustration 1, to see that the transistors of the discrete circuits were essentially replaced by IC amplifiers, which are all contained in a 14 (15) – pins IC with plastic housing of type U161. The price of the IC (as spare part) was 6 dollars. The full possibilities of the integrated circuit were not really used with this equipment yet. The number of the soldered connections differs from a discrete circuit but there are still many external standard elements in the form of LC-circuits, resistances, capacitors and transducers used. Also GE calls this equipment a „test drive“, a sort of learning curve. The radio is not larger than a cigarette box since it features a clever (and compact) structure for the printed circuit.

Fig. 2: General Electric P 1740. General Electric P 1740. First IC (pocket) receiver of the world in 1966. The receiver (above) is removable and works then as usual pocket radios; in the lower part a large auxiliary loudspeaker and the accumulator charging unit are accommodated. There was also a version with alarm clock.
Dimensions:
Radio: 8 × 5.5 × 2.8 cm
Battery charger: 13 × 9.5 × 9 cm.

A battery charger belongs to the set, into which additionally a larger loudspeaker is built (also in a version with alarm clock). When putting the radio on the battery charger (as in fig. 2), the larger loudspeaker is connected, and a quite good sound is produced. In addition a mains supply for the unit is then provided. GE indicates the following data for the equipment:

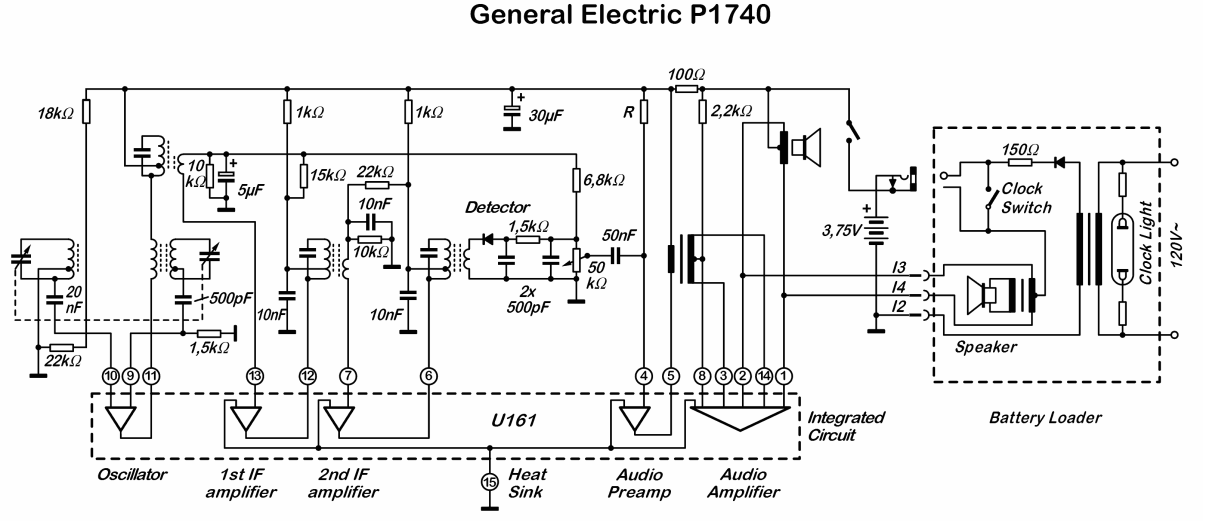

Fig. 3: Diagram of the P1740. Clock switches and clock light do not exist in the execution „without alarm clock“.

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Sensitivity 300 µV, related to 15 mW power output, maximum power output 140 mW, audio frequency range 180 - 2500 Hz (with -6 dB), power input with middle volume 8...9 mA. GE gave 3 years warranty on the equipment and accumulator.

In spring 1967, the company Heath brought the first Hi-Fi Stereo receiver with ICs for FM (and AM), as AR-15 [3] [5]. The equipment contains 69 transistors, 43 diodes and 2 ICs. In the FM Tuner with quadruple adjustable capacitor, 3 FETs are used and the FM sensitivity was given as 0,7 µV.

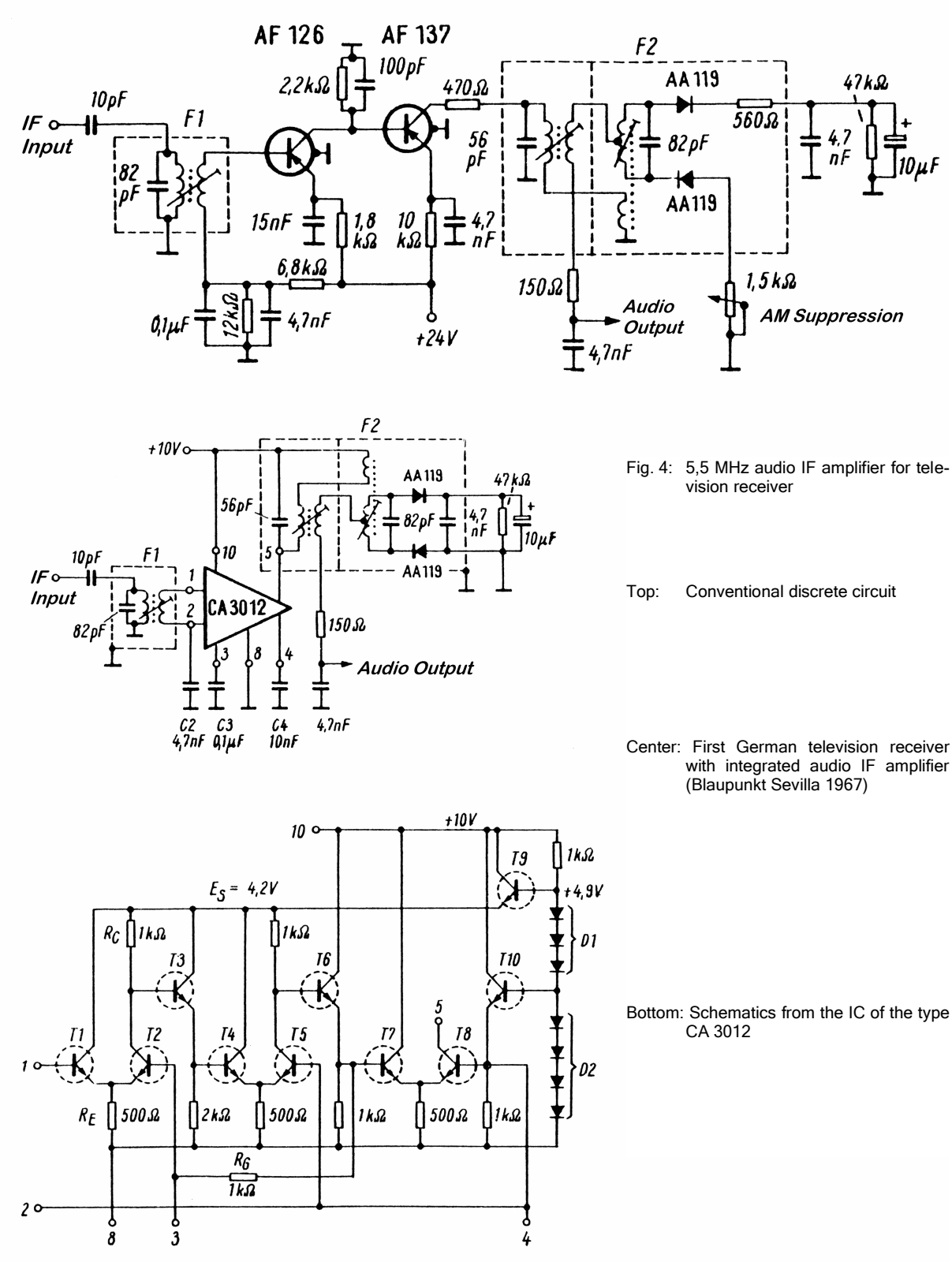

Fig. 4: 5,5 MHz audio IF amplifier for television receiver

Top: Conventional discrete circuit

Center: First German television receiver with integrated audio IF amplifier (Blaupunkt Sevilla 1967)

Bottom: Schematics from the IC of the type CA 3012

With a distortion factor of less than 0.5%, the sinus power output per channel was 50 W. The most interesting part is the intermediate frequency part, where two RCA ICs of the type CA 3012 (monolithic broadband amplifiers - particularly adapted to IF stages in the frequency range from 100 kHz to 20 MHz) in connection with crystal filters are used, whereby, for all signal levels, a nearly ideal (rectangular) transmission curve could be obtained. For reference: conventional intermediate frequency stages with filter, when exposed to high input signals and limitation, show a strong increase of the bandwidth aperture, which leads to increased noise, dropping in discrimination and interference with neighboring transmitters. Normal filter should follow at this point a compromise when used in Stereo devices. If they are made too narrow-band for the above reasons, with strong signals and a not to large bandwidth, then with small and middle signals it is hardly possible to get a Stereo reception. Details to the AR-15 can be read in [3] and [5].

At about the same time as the AR-15, Heath brought also a kit out for full solid state 30 cm TV set, which was likewise equipped with ICs (CA 3013/14) in the audio intermediate frequency part [6].

There were still no IC-equipped standard devices in Europe in 1966. Perhaps it was due to the fact that research was targeted not to replace only the transistors by IC amplifiers but also to replace LC combinations. SEL introduced circuit concepts for a FM receiver on the Hanover Fair in 1966 and afterwards (TV IF amplifiers), even before [7], [8]. Appropriate ICs did not exist at this point of time. Perhaps the circuit integration know-how was simply missing.

With this situation, equipment manufacturers who wanted to use ICs had to look at US types, and it was almost natural that the first German IC-equipped device, the TV receiver “Sevilla” from Blaupunkt, was presented at the Hanover Fair in 1967 with ICs of RCA [9]. The proven type CA3012 was used as 5.5 MHz audio intermediate frequency amplifiers (see [1]). In fig. 4 the conventional execution of the intermediate frequency amplifier stage is compared with its IC version. In principle, and as expected, the differences are small. The advantages of the IC solution are the same as the ones mentioned under [1]: reduction of the elements (and thus the space requirement), improved reliability, very good suppression of impulse noises, excellent AM-suppression and to a large extend, constant audio frequency output voltage with large changes of the high frequency input voltage.

Fig. 5: Philips IC 2000, the first European IC-receiver from 1967 with recharging unit, leather carrying bag and case. Dimensions: radio 7,2 x 7,5 x 3 cm, case 21,8x10,5x4,3 cm.

The first European IC radio could be admired at the Funkaustellung radio exhibition of 1967. Philips introduced it as its pocket radio IC 2000 (fig. 5). The entire circuit of the 5-circuit super is accommodated on a printed circuit using the empty space behind the speaker (fig. 6).

The size of the equipment is essentially the size of the loudspeaker. An integrated rechargeable DEAC cell (3.6 V) provides 5 hours of function. A small power supply unit and/or battery charger was provided for the radio, with which the accumulator could be loaded or the equipment be operated „plugged in“. The „packaging“ for the set has been „borrowed“ from the Philishave shaver department of Philips.

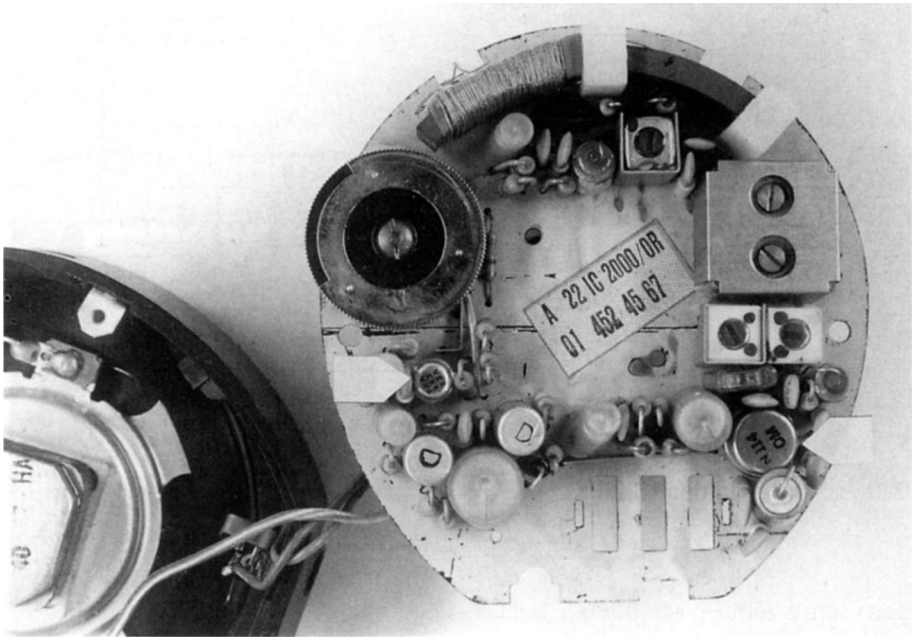

Fig 6: Construction of the IC 2000. The arrow shows both ICs, the DEAC-Akku being removed.

The schematics (fig. 7) shows a mixed design: the self-oscillating mixer with ferrite antenna (BF195, S1, S2) and the push-pull amplifier (AC 127/132) are using discrete components. IF amplifier/demodulator (N114 OM) and audio preamplifier (TAA263) are based on VALVO ICs.

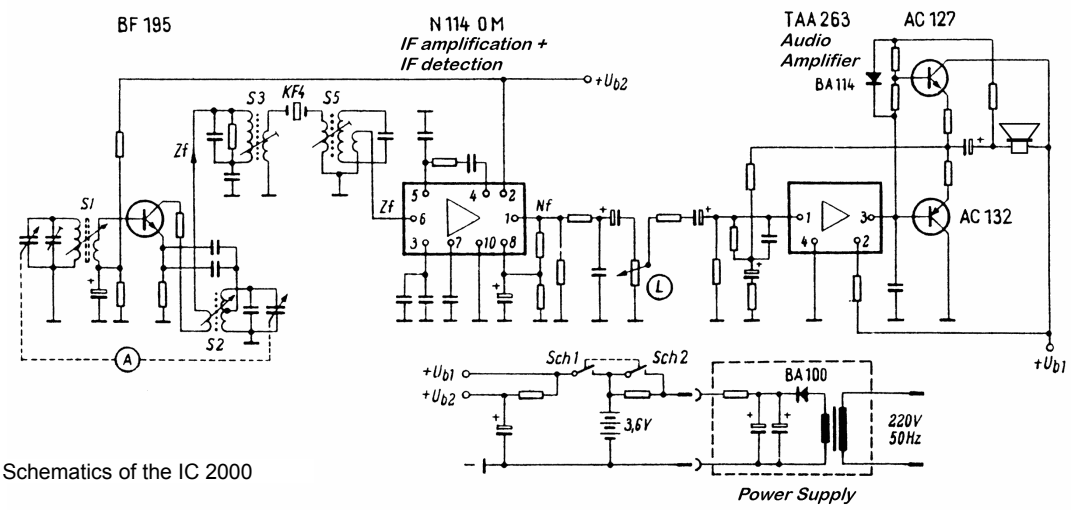

Fig. 7: Schematics of the IC 2000

The interesting point in this concept is that the whole IF selection composed of the circuit S3 and S5, as well as the ceramic filter KF4 are located before the IC. This provides the advantage that, although high gain is achieved, the disturbance modulation due to non linearity can be avoided; other frequencies as the IF could be avoided. The divider located at the audio output of the IC N114 OM (Pin 1) delivers the voltage required by the automatic gain adjustment located at the input of the IC (Pin 8). The audio output signal of the IF amplifier / demodulator is connected to the volume control L through a RC filter. Electrolytic capacitors at both sides block the DC component to avoid noise during adjustments. This volume control is followed by the audio amplifier based on the second standard IC TAA263, which is a direct coupling 3-stage

amplifier. An overall feedback goes from the speaker to the input of the audio amplifier. Philips gave a sensitivity of 400 µV with 50 mW of output power [10].

We are concluding our first overview of the first devices fitting IC technology with the IC 2000. The reliability of Integrated Circuits has been proven since over 25 years: my two radios of this pioneer time are still working.

How did it continue with the implementation of the IC technology? We know the answer: slowly at the beginning and steadily increasing afterwards. We could find then more and more IC technology in TV sets and, from 1970 on, also in radios (portable and auto-radios). Today, ICs are key to all the devices of the consumer electronics. An example for today's possibility can be found on fig. 8, a FM radio of the size of a stamp, from 1991.

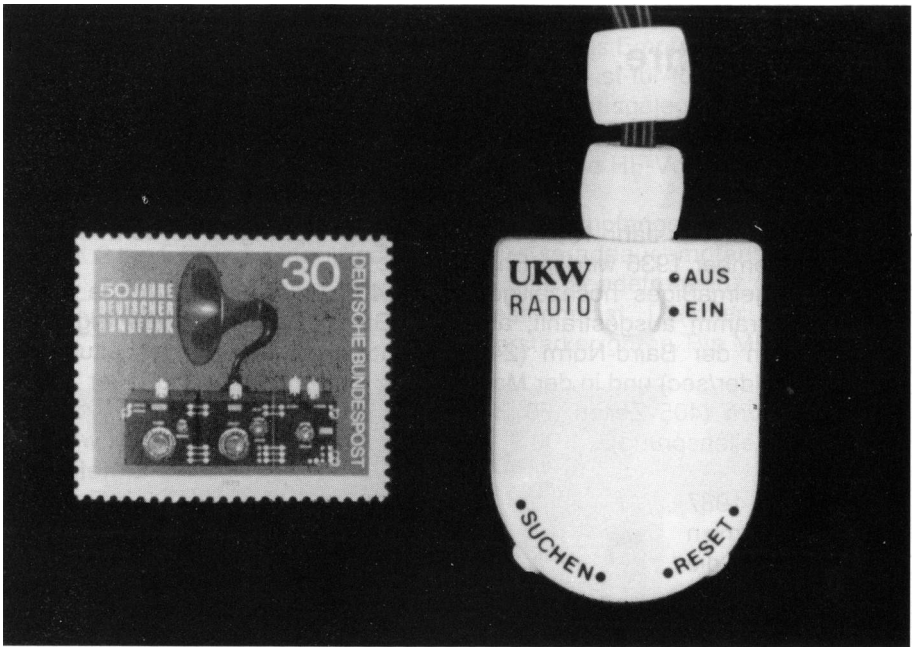

Fig. 8: One-chip IC FM radio with automatic search from 1991 (far East).

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