The introduction of television techniques in X-ray diagnostics has opened up all kinds of possibilities that have proved to be of great practical value [1]. One that has recently been put to use is the subtraction of X-ray images [3].

The principle of the method of image subtraction has long been known: it makes it possible to eliminate certain dominant bone structures, especially bone shadows, if these are not of interest in the examination of a radiograph. This is particularly important in brain examinations where the petrous bone and the eye sockets can often be very troublesome in radiographs of the skull. In one of the methods of brain examination a contrast medium is injected into one of the arteries that supply the brain. The contrast medium is circulated with the blood stream, first filling the arterial vessels during the arterial phase, then entering the brain capillaries, which are so fine that they do not appear separately in the radiograph, and finally being carried away from the brain through the veins (venous phase). This circulation lasts from about 10 to 15 seconds, during which time a series of radiographs is taken. If a radiograph has been taken immediately prior to the injection, and measures have been taken to keep the patient's head immobile during the whole series of exposures, it is then possible to subtract this "empty" X-ray radiograph from each of the circulation radiographs, thus obtaining a very distinct picture of the vascular system in the relevant phase of the circulation.

Originally the subtraction of two radiographs was performed by photographic means, that is to say by copying the negative of one radiograph on top of a transparent positive print of the second [3]. This is a rather cumbersome procedure and great care is required; its application has therefore been limited.

The subtraction of two images can be performed far more easily with a closed circuit television system, as the video signal voltages for two images can at will be either added together (as in picture-mixing in television studios) or subtracted from each other. The following procedure is used for viewing radiographs by this method [3]. One radiograph, in this case the "empty" one in our skull series (fig. 1a) is placed in front of a viewing box and the television camera gives a sharp picture of it on the monitor screen; the video signal of this picture is then recorded in a magnetic store [4]. The next radiograph (fig. 1b) is then placed in the viewing box and observed with the television camera, but this time the signal held in the store is subtracted from the video signal from the camera before the picture is passed to the monitor. The positive and the negative image on the screen can quite easily be brought into correct register by shifting the second radiograph in the viewing box by hand. The resultant subtraction image on the monitor can also be photographed for documentation (fig. 1c).

We have now extended this subtraction method by the application of colour television, which adds as it were another dimension to the image information. In this application we record several radiographs of a series one after another on different tracks of the magnetic store. The signals of two or three of the tracks are then read out simultaneously and — after appropriate subtraction and mixing — are fed into the three colour channels of a colour monitor. In this way, in one and the same picture, we can represent the arterio-vascular system, visible in the first radiographs of the skull series, in a particular colour, say red, and the venous system from one of the later radiographs in a contrasting colour such as blue. The procedure is illustrated schematically in fig. 2. With the system shown in fig. 2 it is possible to subtract from the negative image on the screen can quite easily be brought into correct register by shifting the second radiograph in the viewing box by hand. The resultant subtraction image on the monitor can also be photographed for documentation (fig. 1c).

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(1) Of the numerous publications on this subject, we shall mention only:
J. Feddema and J. E. Marquerick, X-ray television with special regard to a newly developed vidicon: the "Plumbicon", Medicamundi 10, 2-9, 1964 (see also Medicamundi 10, 21, 1964).
G. J. van Hoytema, W. J. Oosterkamp, A. M. C. van den Broek and A. Druppers, La neuroradiologie avec soustraction utilisant la télévision et une mémoire d'image magnétique, Neurochirurgie, in the press.

W. J. Oosterkamp, A. P. M. van 't Hof and W. J. L. Scheren
Fig. 1. a) Radiograph of the skull before injection of a contrast medium in a main artery. b) A few seconds later: the contrast medium has spread through the arterio-vascular system. c) Radiograph (a) has been subtracted from radiograph (b), thus eliminating the dominant bone structures.

Fig. 2. System for image subtraction using closed-circuit colour television. The radiograph $F_0$ taken without contrast medium is placed in the viewing box $L$ and viewed by a television camera $Cam$, after radiographs $F_A$ and $F_V$, taken with the contrast medium in the arterial and in the venous systems, have been televised in the same way and recorded in the magnetic wheel store $Mem$. $Sub$ is the subtraction circuit that supplies the colour difference signals $R$, $G$ and $B$ indicated in the figure which are applied to the red, green and blue channels of the colour monitor $Mon$ respectively.
we obtain a colour picture with a light background (fig. 3) \[5\]. By using other combinations of signals one can also obtain a colour picture with a very dark background.

Apart from this application of X-ray colour television, where the difference between the individual radiographs is due to the movement of the contrast medium with the blood, many other applications are possible. Differences between images of the same object may also be due to the movement of the organ itself, to different angles of projection, to the use of X-rays of different hardness, to the successive introduction of contrast media in neighbouring organs, and so on. Colour display, which is relatively easy by the method described, will certainly be of instructional value, and may prove to be of practical interest through an increased facility of observation. The future will show to what extent this system will be able to assist the radiologist in diagnosis.

\[5\] The three radiographs used as starting material were placed at our disposal by Prof. B. G. Ziedses des Plantes of Amsterdam.