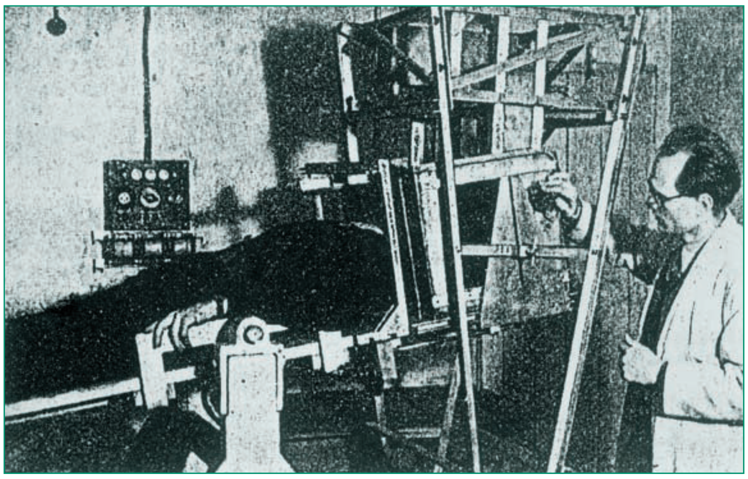
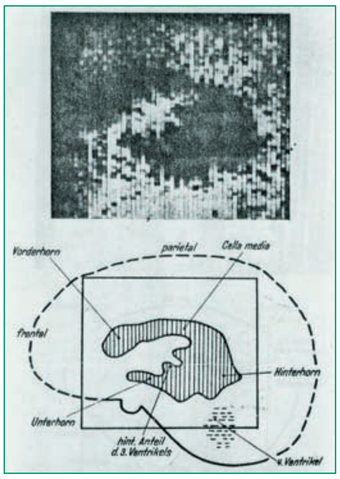
Pioneers of Medical Ultrasound

UltraschallMuseum

K. Th. Dussik



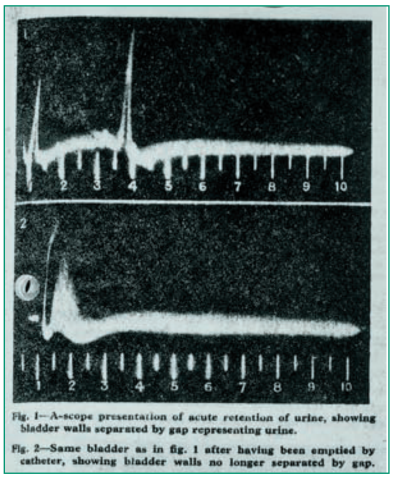
The machine, constructed by Dussik and his brother



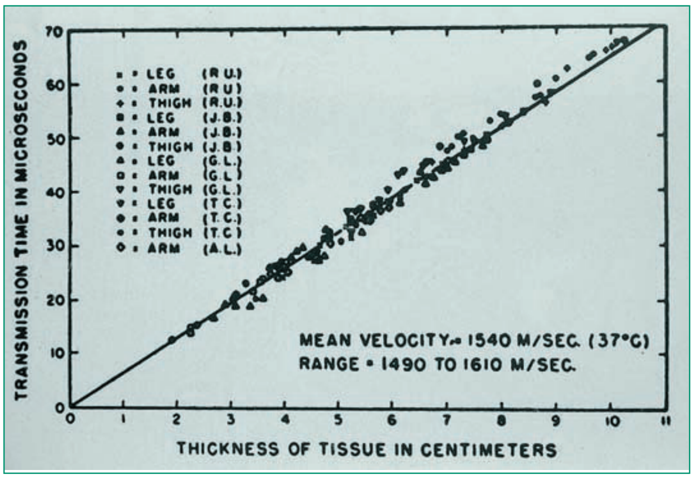
Hypersonogram of the 3rd ventricle

K. Th. Dussik, neurologist in Vienna, was the first physician, who tried to use ultrasound for diagnostic purposes in medicine.
In **1942** he published a method of depicting the cerebral ventricles named "hypersonography" Transmitter and receiver were placed at opposites sides of the skull in fixed relations. The intensity of the signal was recorded on a film.
By moving the probe line by line across the skull, a two-dimensional image was created, giving information about changes in absorption of ultrasound (in analogy to classical x-ray).

G. Ludwig



A-scan of the bladder, before (above) and after miction



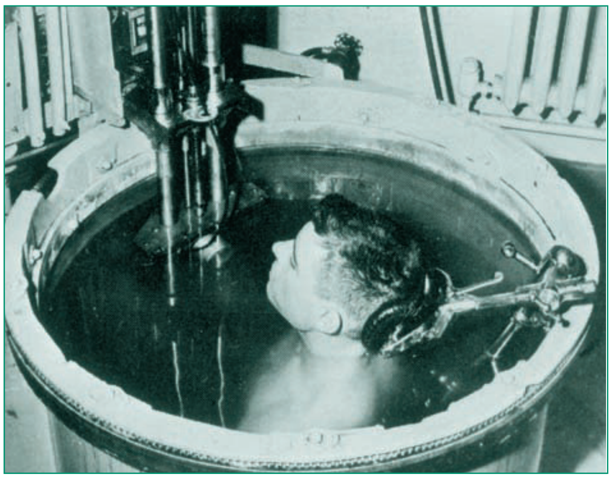
Ultrasound velocity in different soft tissues

In **1949 G. Ludwig** (Pennsylvania) presented the first application of a pulse-echo-device (echo-ranging) in medicine. For the detection of gallstones he used a device, which was originally designed for nondestructive material testing (A-mode).
Ludwig reported an accuracy of around 85% in vivo.
Another one of his important works was the exact measurement of the volocity of ultrasound in different types of soft tissues.

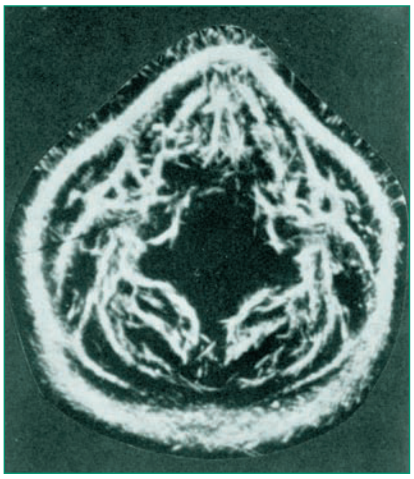
First Medical Applications

UltraschallMuseum

Douglass Howry



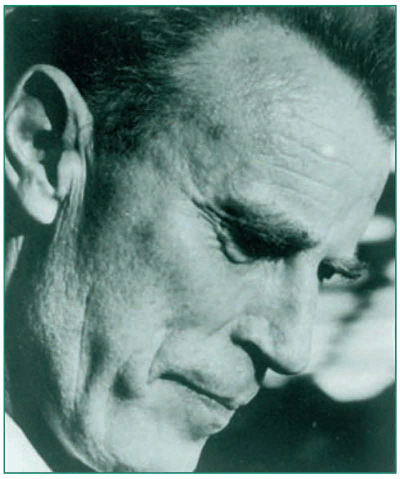
The “gun turret scanner“



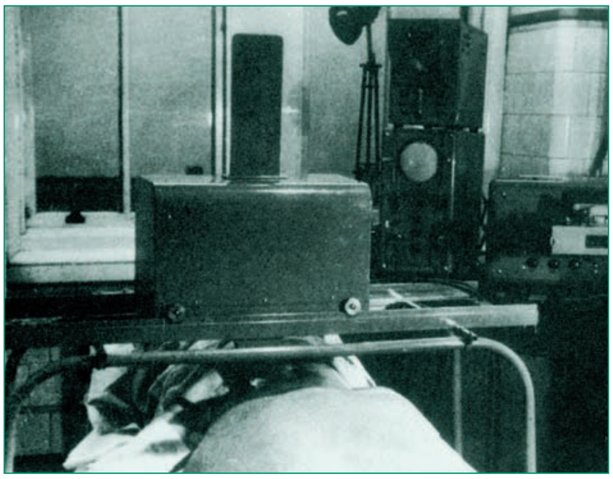
B-scan image of the neck

D. Howry (Denver) was the first pioneer, who in **1952** presented twodimensional ultrasound images in cooperation with the engineer **R. Bliss** The examination was carried out with the patient sitting in a water-filled tub. For examinations of the neck the patient therefor hat to be immersed in the water almost to the tip of the nose. The Scanner repeatedly made semicircles around the patient .

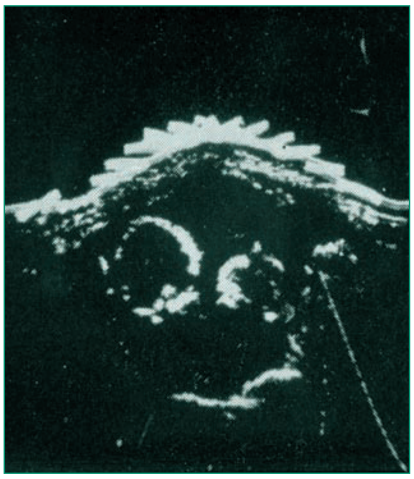
Together with **Joseph Holmes** he examined mainly the organs of the andomen, the liver, the spleen, the kidneys and the urinary bladder.



Ian Donald



First contact-compound-scanner. The probe was moved by hand in direct contact to the skin



Twins

J. Donald (Glasgow) constructed the first contact-compound-scanner in **1957**.

Instead of immersing the patient in water, ultrasound gel war placed between the transducer and the body. Now the ultrasound probe could be moved manually on the skin.

Donald diagnosted twins, triplets, hydramnios and fetal anomalies (hydrocephalus).

He propagated the use a full bladder as an acoustic window. The contact-compound-scanner became the basis for large-scale use of diagnostic ultrasound in medicine.

Doppler-Sonography

UltraschallMuseum

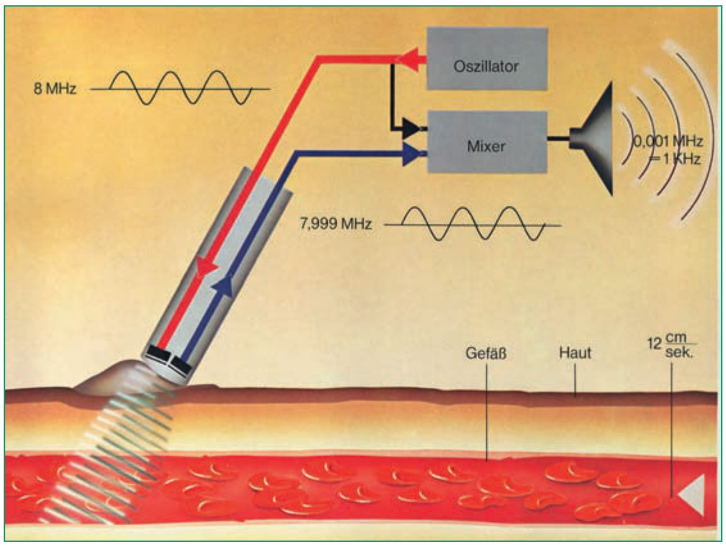
Christian Doppler

Diagnostic ultrasound gained new perspectives from the use of "Doppler-Sonography", named after the Austrian physicist **Christian Doppler (1803 – 1853)**. He discovered that the frequency of waves – including sound waves – will shift, when the origin of the waves and the observer will move relative to one another.

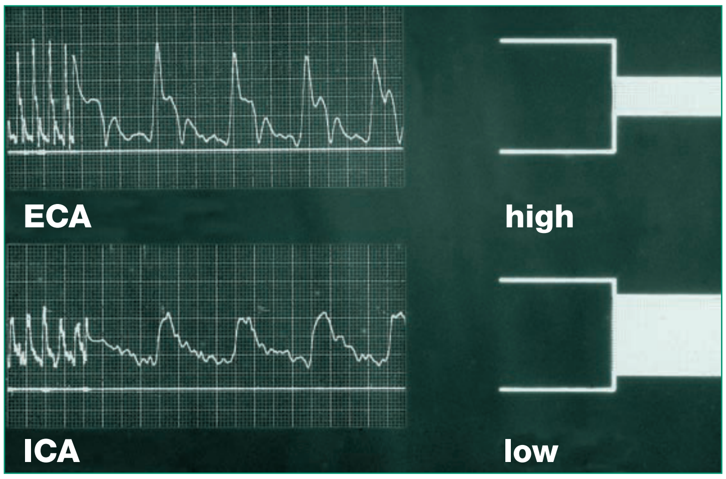
For example, if a source of sound of a constant pitch is moving towards an observer, the sound seems higher in pitch, whereas if the source is moving away, it seems lower.

Correspondingly, the frequency of diagnostic ultrasound (about 1 – 20 MHz) will change to a higher or lower pitch when reflected or scattered at moving corpuscular elements within a living body, especially blood cells.

Examining blood vessels with 2 – 8 MHz ultrasound, the shift between emitted and reflected sound waves is approximately in an audible range of 50 Hz – 20 kHz. Knowing the frequency shift and the angle of insonation, one can calculate the velocity of the blood flow.



Principle of Doppler-sonography



Continuous-wave Doppler-sonography (about 1978)

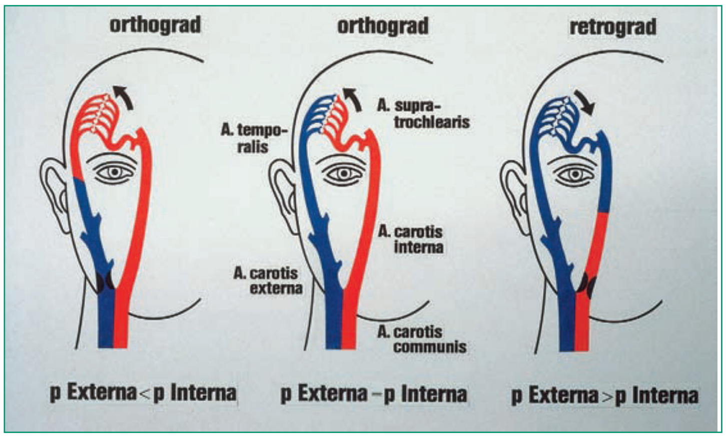
Variations between systolic and diastolic blood flow patterns are specific for certain blood vessels. A change of these proportions or a very high or very turbulent flow indicate a vessel stenosis. A missing ultrasound Doppler shift would be typical for an occlusion. In veins not only the spontaneous but also the augmented flow patterns are relevant – for instance after compression of more distant veins.

Experienced sonographers make their diagnoses by listening to the ultrasound Doppler-flow signals. Documentation either as a graphical curve or, after "Fast Fourier Transformation" (FFT), as a time-frequency spectrum.

Doppler-Sonography

UltraschallMuseum

Systolic blood pressure



Periorbital circulation

Fields of application

Obstetrics: Registration of fetal heart beats and umbilical cord vessels (*Kratochwil* 1967, *Weber and Stockhausen* 1967).

Peripheral arteries: First application 1959 (*Satumura*). Measurements of systolic blood pressure at the limbs, detection and quantitative evaluation of a peripheral arterial circulatory insufficiency (*Schoop* and *Levy* 1969, *Bollinger, Mahler* and *Zehender* 1970).

Peripheral veins: Detection of thromboses and valvular insufficiency (*Bollinger* and *Mahler* 1968).

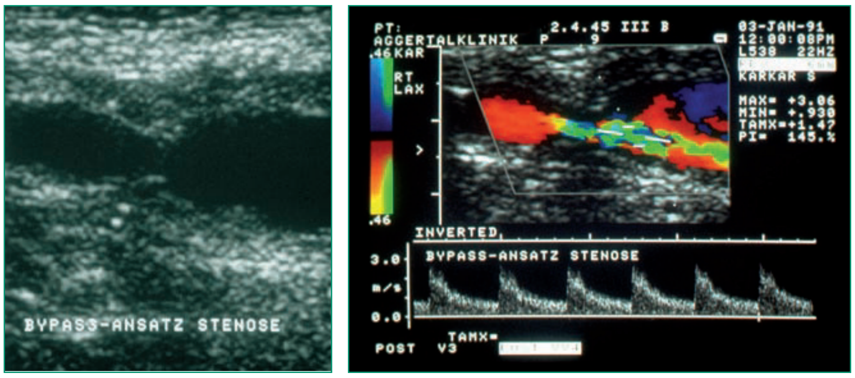
Extra- and intracranial arteries: Indirect Doppler-sonography via periorbital arteries (*Müller* 1972). Direct insonation and differentiation of the arteries of the neck (*Büdingen*, *von Reutern* and *Freund* 1976). Examination of intracranial arteries (*Aaslid* 1982). Experimental use of diagnostic ultrasound for supporting thrombolysis after stroke (*Alexandrov* 2002)

Cardiology: Intracardial flow measurements by *Seipel* (end of the 1960ies), Doppler-echocardio-graphy (*Hatle* and *Angelsen* 1982)

Duplex-Sonography

In duplex-sonography a single ultrasound probe combines pulsed Doppler-sonography with B-mode sonography to enable flow-measurements in a visually defined region of interest.

In *colour-coded duplex sonography* a net of Doppler-sonographic sample volumes is virtually spread over the B-mode picture. Average Doppler shifts are coded in various colour shades and are superimposed to the B-mode picture of an organ, with flow velocity and flow direction being displayed in different colour hues (*Baker* and *Strandness* 1974). This method makes it easy to find blood vessels within tissues and to look for best Doppler-sonographic measurement points, for instance behind cardiac valves or in stenotic vascular regions.



Colour-coded display of bypass-stenosis

History of Ultrasound in Medicine

UltraschallMuseum

Part I Pioneers (< 1940)

1793 **Spalanzini** Spalanzini postulates a sixth sense in bats, later assumed to be an "ultrasound-sense" (1920), proven not before 1939 (*Griffin* and *Galambos*).

1842 **Doppler** detects the relative frequency shift of moving sources (redshift of double stars) – the *Doppler-effect*

1877 **Strutt** describes the physical principles of sound, "The Theory of Sound"

1880 The **Curie**-brothers detect the piezoelectric effect

1912 **Behm** and – independently – **Richardson** invent the sonar

1916 **Langevin** and **Chilkowsky** construct the first ultrasound generator and the equipment for underwater detecting of submarines

1929 **Sokolov** develops the nondestructive ultrasound test of different media

1929 **Wood, Loomis** and **Johnson** start first studies of ultrasound bioeffects

1936 **Gohr** and **Wedekind** discuss ultrasound examination of inner organs

1939 **von Pohlmann** introduces ultrasound in therapy

Part II First Attempts (< 1952)

1942 **Dussik:** First attempts to use ultrasound transmission in medical diagnostics ("hyperphonography" of the cerebral ventricels)

1949 **Keidel:** Volume measurement of the heart (transmission-technique)

1949 **Ludwig** and **Struthers** use a pulse-echo-device (material testing device)

1950 **Wild** and **Reid:** Tissue characterization with ultrasound

1951 **Wagai:** Diagnosis of gall stones and cancer via water bath-scanner

1959 **Satomura:** Transcutaneous Doppler sonography of cervical and peripheral vessels

History of Ultrasound in Medicine

UltraschallMuseum

Part III Clinical Applications (> 1950)

1952 Howry and **Bliss:** First two-dimensional ultrasound image sector scanner (water bath)

1952 Wild and **Reid:** Two-dimensional imaging of body structures, first endoprobes

1953 Edler and **Hertz:** Echocardiography (TM-mode)

1954 Leksell: Echoencephalography (A-mode)

1955 Howry and **Bliss:** First compound scanner (water bath)

1956 Mundt and **Hughes:** Ophthalmography (A-mode)

1957 Donald and **Brown** First contact-compound scanner

1958 Baum and **Greenwood** Ophthalmography (B-mode, Compound-scanner)

1961 von Ardenne and **Millner:** Focoscan for horizontal slices (C-mode)

1964 Schentke and **Renger:** Tissue characterization by A-mode technique

1965 Krause and **Soldner:** First automated real time scanner (Vidoson)

1965 Holländer: Real time in Obstetrics and Gynecology

1966 Strandness jr.: First commercially available CW-Doppler equipment in the Western hemisphere

1967 Watanabe: Transrectal scanning of the prostate

1969 Rettenmaier: Real time scanning of the abdomen

1969 Kratochwil: First biopsy transducer for a compound scanner

1972 Greene: high performance ultrasonic camera (acoustical holography)

1972 Holm: First biopsy transducer for real time scanner

1973 Carlsen and **Garrett:** Gray scale technique

1974 Baker and **Strandness:** First prototype of duplex system

1974 ADR 2130: First commercially available linear array scanner

1986 Aloka Quantum: First color coded duplex-sonography