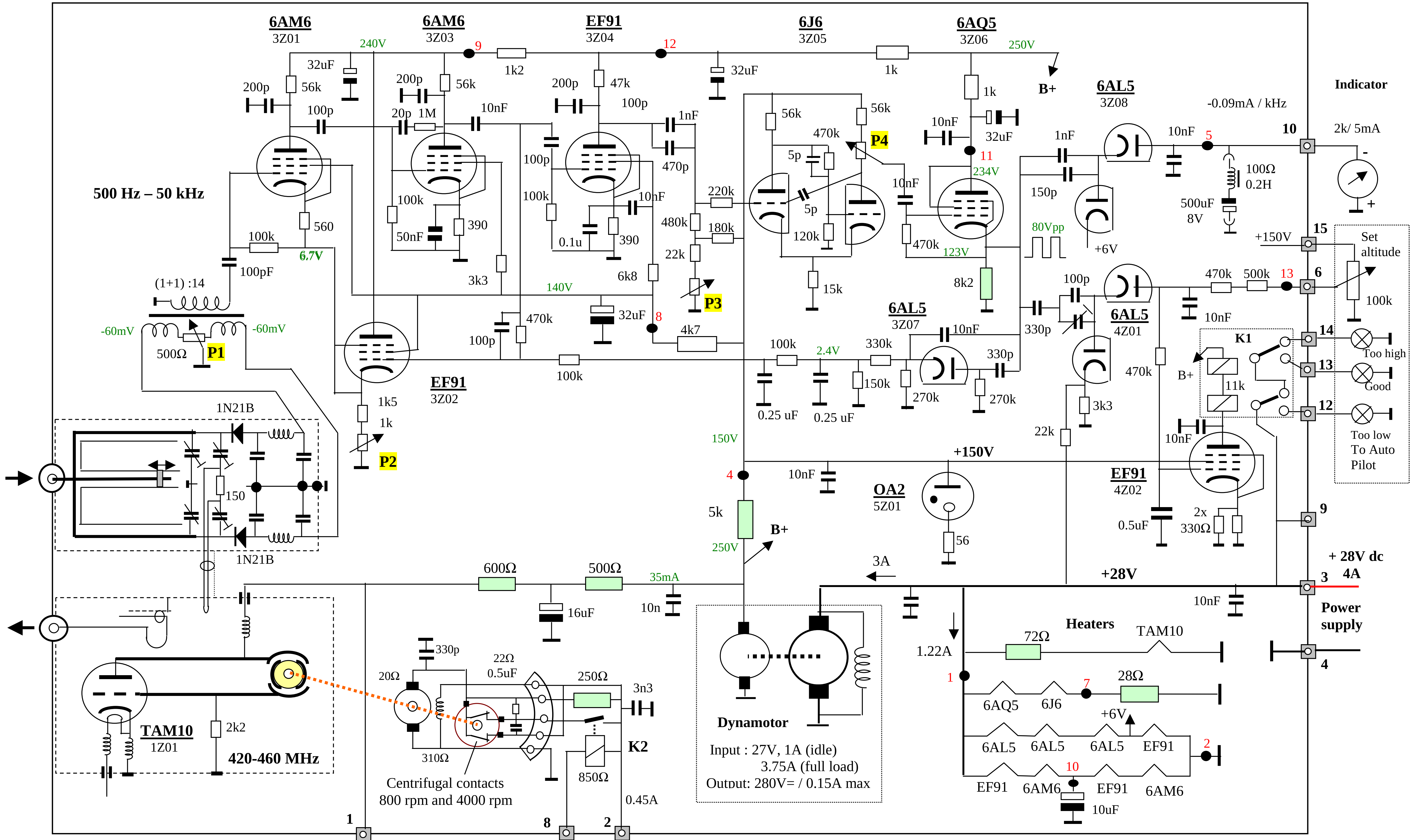
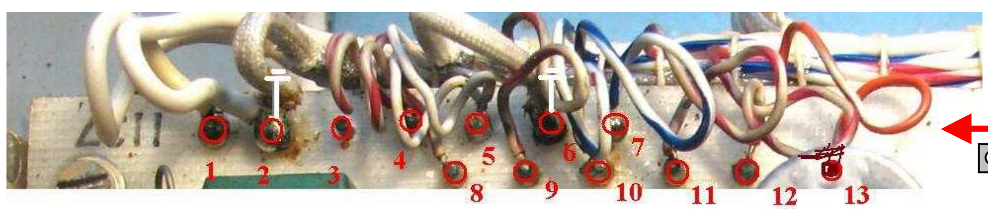
For details see page 2





See photo for RED numbers.
Black numbers on main connector

RADIO ALTIMETER AM 210

Made by C.S.F in 1956

Reverse engineered 25 August 2009 kb

Radio Altimeter
AM210

Radio Altimeters were developed during WWII, like in 1943 the AN/APN-1. They had a small transmitter that was frequency modulated with a low frequency, shifting the carrier frequency continuously between 420 and 460MHz. The receiver measured the frequency difference between the transmitted signal and the signal returned from the ground, that has the transmit frequency from a few us earlier.

The 420-460MHz band was abandoned in 1963, when radio altimeters were operating in the 4200 – 4600 MHz band

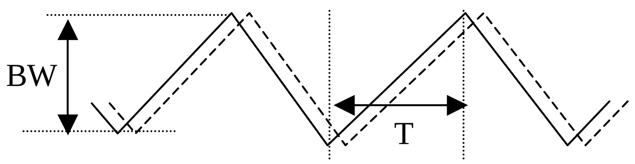
The APN-1 had sinusoidal FM, produced by a voice coil driven membrane as variable capacitor, which tuned the transmitter. The APN-1 had 2 altitude ranges (0-400 feet and 0-4000 feet). In the low range, the amplitude of the membrane was much higher than in the high altitude range.

The AM210 is a French development with nearly the same circuit as the APN-1, but with miniature tubes, and triangular FM in stead of sinusoidal.

In the 15.5 x 26.5 x 33 cm case, the transmitter is on the right. The big black dome is a centrifugal speed controlled dc motor, which drives a variable capacitor for frequency modulation. The gold plated pipes in the middle are the receiver input circuit, matching the antenna to the balanced mixer in a gold plated box.

Theory

In the graph below, the solid line is the transmitted frequency versus time, whereas the dotted line is the frequency of the received echo.



BW = peak-to-peak frequency deviation
T = time to deviate from min to max,
dF = frequency difference between received and actual transmitted signal
c = speed of light (3.10 ^ 8 m/s = 983 feet / µs)

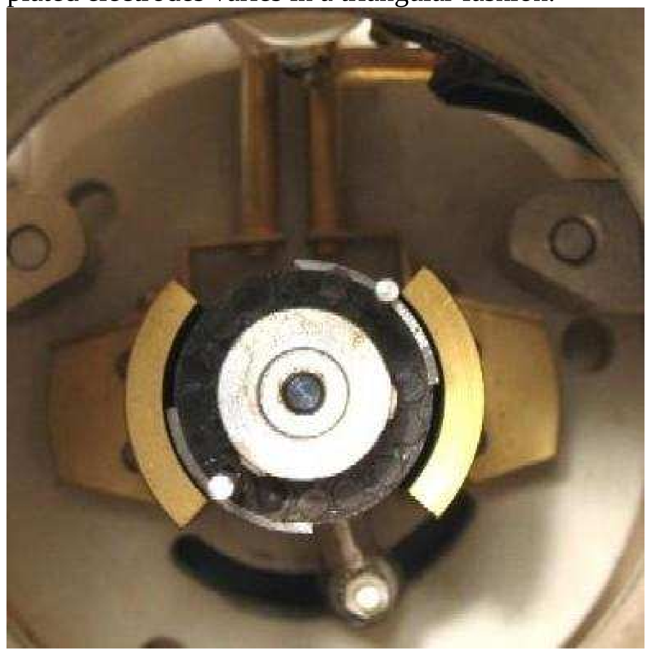
With these parameters we find the altitude H:

2 x **H = c x dF x T / BW**

From the value found, a known value is substracted for the length of the coax cables to the antennas, plus the path from one antenna to the other via the ground when the aircraft is on the platform. This minimum distance sets a minimum frequency difference, and the low frequency amplifier can be ac-coupled even for an altitude range down to zero feet.

Transmitter

The transmitter is a single TAM10 triode, with a special rotating capacitor as tuning element. When the disc in the centre of the picture below rotates at constant speed, the capacitance between the two gold-plated electrodes varies in a triangular fashion.



FM motor

A dc motor drives the rotating capacitor. The rotor of this motor is switched on and off by a centrifugal contact, mounted on a small disc, and connected by slip rings and brushes.

In fact, there are two contacts, one opening at 800rpm, the other at 4000 rpm. Which one controls the speed is selected in the cockpit. The lower speed is used for high altitude, with a useful range of 0-5000 feet, the high speed for the low altitude range of 0-1000 feet. The measured altitude is proportional with the speed of this motor, so the gap in the centrifugal contacts is critical and probably needed frequent cleaning and adjustment.

The chopping frequency of both contacts is about 600Hz. The rotor current chops between zero and 1A, average 0.4A at 27V dc. Speed fluctuations can be clearly heard at the lower speed.

Receiver

The received signal has a frequency that slightly differs from the transmitted frequency, this is the altitude information. But, the received signal also has significant amplitude modulation due to the antenna and coax impedance variations over frequency, and the tuned input circuits used.

To eliminate the amplitude modulation, a balanced mixer is used. In fact, amplitude variations give an in-phase output signal , which is not transferred by the input transformer. However, a received signal with frequency different from the transmitted signal give opposite output signals, and these are transferred to the low frequency amplifier.

Low Frequency amplifier

The LF amplifier has a sharp cutoff below 500Hz to suppress AM due to the 133Hz or 27Hz FM. Anyhow, the delay in coax cables and antenna height sets the minimum expected frequency to about 600Hz with the aircraft on the ground.

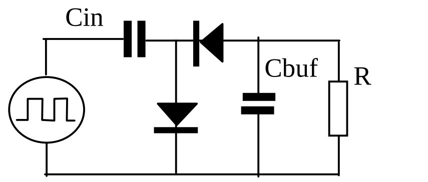
With more altitude, the reflected signal has a higher frequency difference but lower level. To compensate, the amplifier gain rises with the square of the frequency. Here are some data for the required input signal (between the two mixer outputs) to get 10Vpp at the grid of the 6J6. Above 6Vpp, the 6J6 produces a square wave of constant amplitude.

Freq	Input mVpp	Gain	Output pin 10 into 10kΩ
500Hz	340	30	0.476 V
1 kHz	15	670	0.94
2 kHz	6.4	1350	1.80
3 kHz	2.7	3700	
5 kHz	0.6	17000	4.47
10 kHz	0.2	50000	8.77
50 kHz	0.15	65000	22.5
70 kHz	0.2	50000	23
100kHz	0.6	17000	

The output of the LF amplifier is a cathode follower, giving 80Vpkpk square wave to the frequency-to current converters. This signal is also used to reduce the gain of the low frequency amplifier.

Frequency-to-current converters

At each rising edge of the square wave, Cin is charged to the amplitude E of the square wave., and



holds a charge of Cin x E coulombs. At each falling edge, Cin is dis-charged into the load R. Both R and Cbuf must have a low impedance, so the output voltage remains small compared to E.

When this process is repeated F times per second, the average output current is F x Cin x E. The output current to pin 10 is –0.09 mA/ kHz.

Autopilot relay

A second F-to-I converter output is compared to a "set altitude"potmeter in the cockpit. The difference drives two relays for the autopilot, with contacts for too high – normal – too low.

Power supply The radio altimeter runs from 27Vdc at 4A max.