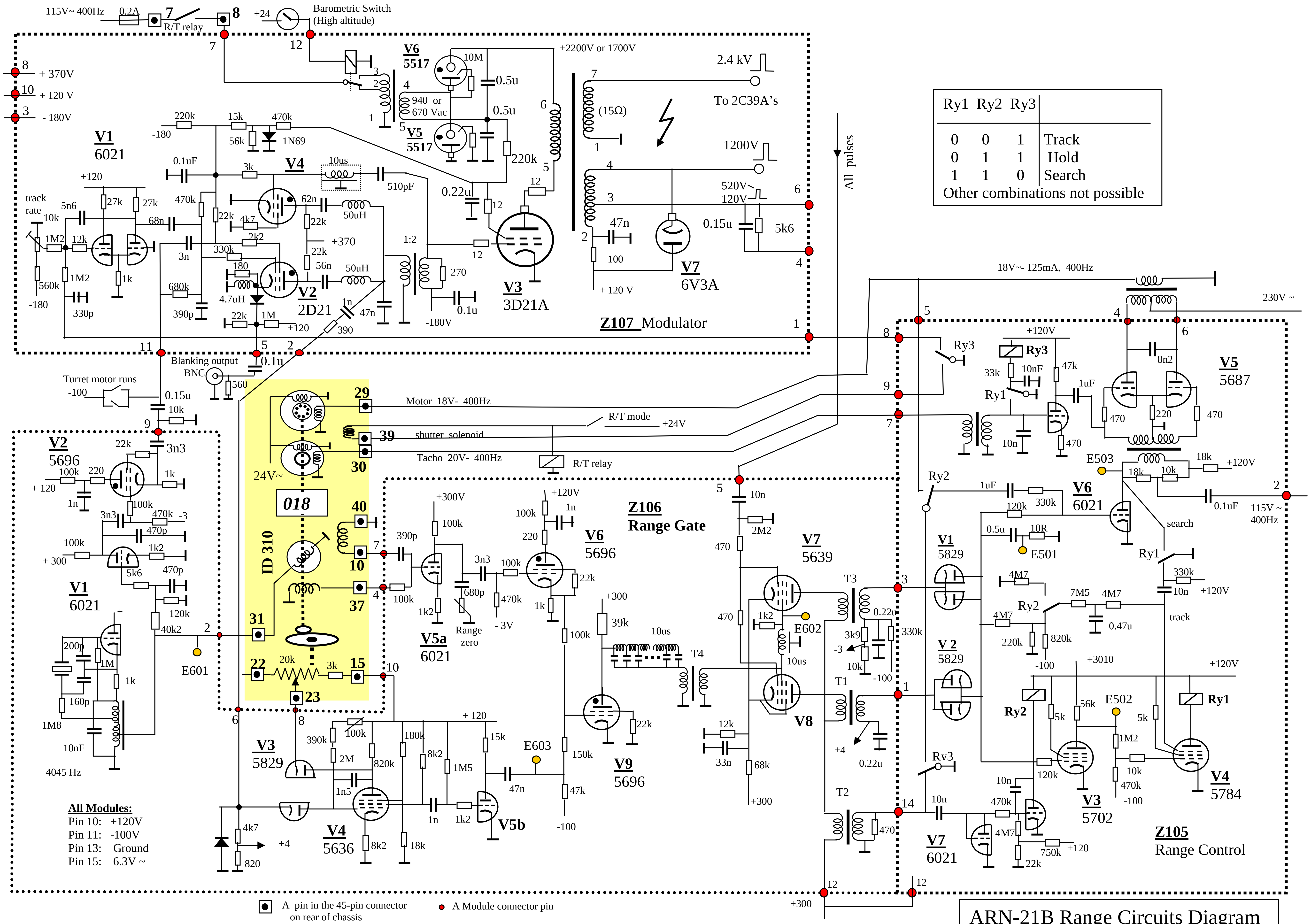
See page 2 for details.



ARN-21B Range Circuits Diagram

RT220B – Range circuits

The range circuits are

Z107 Modulator
Z106 Range gate
Z105 Range control

Tacan range measurement is based on the time-of-flight measurement of pulses that are sent from the airborne unit (interrogation) and responded by the ground beacon. The pulses are sent by the aircraft at irregular intervals, and the airborne unit has to search in the great many pulses received from the beacon those that have a (near) fixed delay from its own interrogations.

Z107 Modulator

The modulator has the high power circuit, a pulse repetition frequency (PRF) generator, a double pulse former, and muting circuits.
The free running PRF generator operates at approx. 23 to 28 Hz in track mode (see later) or 150Hz in **search** mode. Start of a new cycle is triggered by a pulse from the 4kHz Xtal oscilator on the range gate module, so transmit pulses always coincide with a 4kHz pulse. In fact, a twin pulse is transmitted. The first pulse starts with the breakdown of thyratron V2, which pulses the grid of the HV tetrode. The resulting 3µs rounded-rectangular pulse is transformed and provides the anode voltage for the RF transmitter triodes. A 10µs delay line triggers the second thyratron V4 to make the second transmitter pulse. The distance between the pulses is 12µs. When the aircraft altitude is over 30000 ft, the air is too thin for 2.4kV pulses. In that case, a barometric switch and relay extends the primairy winding of the modulator supply transformer, reducung the dc voltage from +2200V to +1700V.

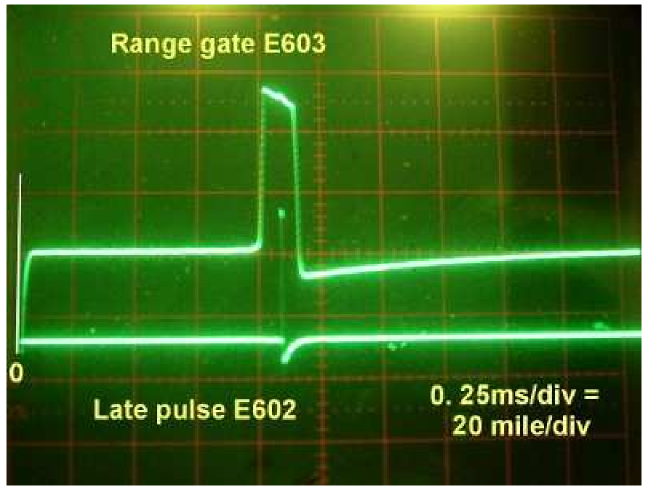
Muting
When the channel selection motor runs, both thyratrons are cut-off by -100V on the grids. Transmitter action is blocked, mainly to protect the mixer diode when cavity pairs are switched.
On the cockpit control panel, either REC (receive only) or T/R (transmit/receive) can be selected. This switches the 400Hz supply voltage to the modulator.
Without high voltage, both thyratrons are cut-off, so the BNC "SUPPR" pulse output on the front of the ARN21 is off as well.

Z106 Range gate

The range gate circuit generates two adjacent, short pulses, the early and late gate, at a "fixed" time after each transmitted pulse. This fixed time is proportional with the <u>number</u> on the range indicator, while it is made by a potmeter and resolver inside the range indicator.

The potmeter
Tube V4 is a phantastron circuit, a one shot that starts at each transmitted pulse, with a pulsewidth from 40 to 2500µs depending on the potmeter position in the indicator. The higher the voltage on the wiper, the longer the pulse. Triode V5 converts the end of the phantastron pulse into a 0.2 ms pulse, E603 in the oscilogram below. When the indicator motor runs, this puls runs on the osciloscope screen in 20 seconds from left to right and then repeats. The span of the indicator is 200 nautical miles, which corresponds to 50 + 200 x 12.36 = 2522 µs (time of flight plus beacon delay).

The resolver
The required 0.1% range accuracy is provided by the circuit around the resolver, a rotary phase shifter like the one in the bearing indicator. This resolver is fed from a very low (!) frequency Xtal oscilator at 4045 Hz . Each cycle of this frequency corresponds to 20 miles. The resolver is geared at 10 times the speed of the potmeter and phase shifts the 4kHz signal with the aid of a matched RC circuit. V6 converts the shifted sinewave to 4kHz pulses. When on the oscilogram below, 10 pulses would be visible, walking from left to right at the same speed as the single pulse at E603. In fact, V9 triggers on the one that coincides with the pulse on E603.



Early and late gates
When triggered, the delay line in the anode of V9 is discharged, producing a rectangular pulse with 10µs width. This is the "early" gate. A second delay line delays this pulse by 10µs to form the "late" gate, testpoint E602. During these gate pulses, pentode V7 resp. V8 *can* conduct, and will pass any received pulse at that moment.

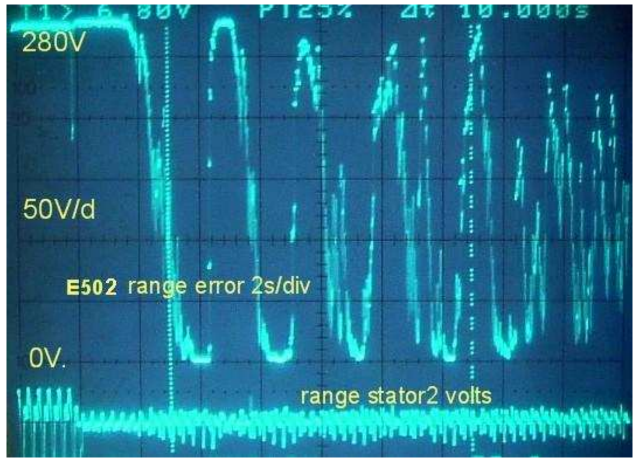
Z105 Range control

Range measurement is a two step process, starting with *search* and then *track*. During search and in REC mode, a red shutter covers the range display.

Search mode
Initially, V3 is off, E502 is +280V, and V6 is on, so Ry1 is activated. In this mode, the system *searches* for replies and the range instrument motor runs at full speed, scanning the range gate from 0 to 2.5ms every 20 seconds.
During the search process, the ARN21B transmits at PRF = 150 (double) pulses per second, so 150 replies/s are received. The range gate passes a 10 µs wide window in 20 sec x 10/2500 = 80ms.
If a reply coincides with the early gate, then V3 is driven a little more positive, and the voltage on E502 drops. When the range gate passes the moment that the replies arrive, then so many positive pulses arrive at the grid of V3 that V6 is turned of, and Ry1 drops off. This ends the full drive of the motor, which brakes from 7000rpm to zero in approx. 1.5 s., and gives an overshoot of approx 1 mile on the display. The branch with 7M5 and 4M7 then drives the motor back by a fixed amount, hopefully equal to the overshoot. This should bring the error near zero, and the track control takes over.

Track mode
Once in track mode, the PRF is reduced to 20Hz, so every 50ms there is a received pulse, that more or less coincides with the early or late window.
When the reply coincides with the early gate there is a 1V negative pulse on E501, when it coincides with the late gate there is a 1V positive pulse. This drives the motor a little forward or backward, so the reply pulse is maintained ("cradled") exactly between the early and late gate pulse. As can be seen in the next oscilogram, the servo loop converges to track with a few oscilations of 0.3Hz, probably the bandwidth of the loop. The displayed value doesn't change more than 0.2 miles and looks pretty stable.

Track detection speed
Relay Ry1 must be fast. The range gate at full speed passes the replies in 80ms. Assume that 8 pulses are needed to detect that these are really the own replies, this takes 8 x 7ms= 56ms. So the relay must drop in 24 ms !



The glitch at the first division is the moment that the range gate passes the replies at full speed. At that moment, relay Ry1 drops off, the PRF is reduced, the motor voltage becomes low (lower trace), the back-off process starts, and the red shutter is removed from the indicator display.
The indicator comes to stand still in 1 sec, and inches back a fixed amount in the next half second. After this a damped oscillation starts until in stable track mode. Especially at short range, damping can take over 10 cycles with the instrument I have.

Hold mode
A hold circuit is added to prevent a new search cycle in case of short interruptions of the replies, like during aircraft maneuvers or ID transmissions.
Such interruption is detected by V7 and activates Ry2, which shorts the motor. No problem, the motor voltage was already near zero. With shorted motor, the range indicator stays were it was, and the shutter stays open. When replies come in again, the range gate is still at the correct time, and track resumes.
If no replies arrive in 10 sec, then Ry1 is activated and a search cycle starts.