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Final Report for JRC (Ispra)
Contract No. 2236-83-11
(related DoE Contract PECD 7/9/175-153/83)

"Development of a low frequency transponder system for penetrator instrumentation"

C.G. Flewellen

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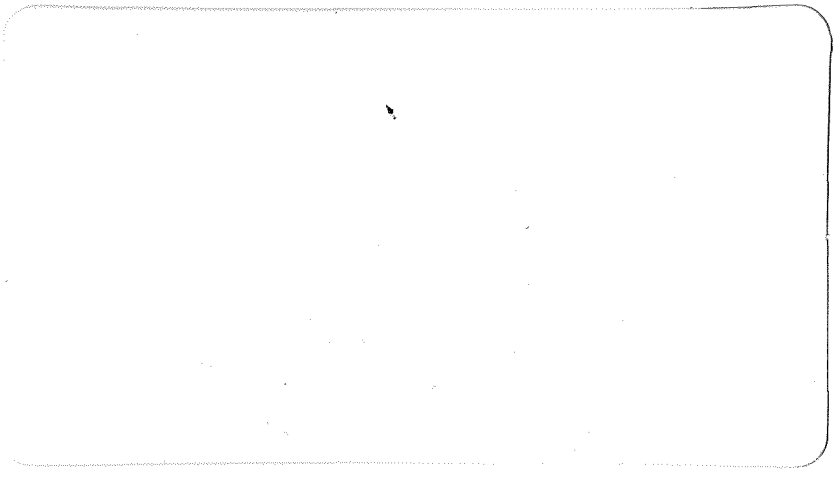

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Contents

1. PROJECT TITLE

Development of a low frequency transponder system for penetrator instrumentation.

2. OBJECTIVES

2.1 To create and demonstrate a technique whereby

(a) the penetrated depth and position of a model HLW penetrator embedded in deep ocean sediment may be determined, and

(b) a communication channel to the penetrator may be established to telemeter parameters measured in-situ.

2.2 To transfer to a competent industrial organisation the technology necessary to manufacture, test, operate and market this technique world wide.

3. INTRODUCTION

For convenience the work can be considered in two phases, A and B.

Phase A consisted of the design of a 3.5 kHz transponder, the construction of 3 units, testing one on 'Discovery' Cruise 141 (October 1983), and testing two on 'Tyro' in March 1984, with provision of penetrators and other mechanical work by BRE, and the loan by IOS of essential associated ship-based equipment.

In Phase B the detailed interests of DoE and JRC diverged and became the subject of separate extensions to the Phase A work. Phase B for JRC consisted of acquiring a number of transponders and the ship-based receiving equipment. The first part of the ship-based electronics was delivered to the JRC in December 1984 and completed in 1985. A desk top transponder and 6 fully operational transponders were ordered by the JRC and it is expected that these will be delivered in July 1986 in time for the international hole closure experiment (HOCUS) planned for September 1986 in Jabuka Trench in the Adriatic.

As work developed on the transponder, the JRC became interested in the possibility of the system to transmit information over long time periods from deep sea sediment formations and re-transmit this data from a surface receiver via the European Space Agency's Meteosat satellite communication system. The Institute of Oceanographic Sciences provided a signal format for the transponder so that the JRC could undertake tests in the North Atlantic during the international long core cruise,

June - July 1985 on the Marion Dufresne.

4. TECHNICAL STATUS

4.1 General The choice of the frequency of 3.5 kHz for the acoustic link between buried penetrator and ship is justified, following a theoretical assessment, for three reasons: an acceptable level of signal attenuation in the sediment, an available transducer of moderate size capable of handling the necessary power, and several widely used seismic reflection profiling systems operating at this frequency which can form the shipboard end of the link.

By making the penetrator unit a transponder, the penetration depth is obtained directly by the profiler interrogation when the ship is overhead. Using ship navigation whilst manoeuvring within transponder range the geodetic location of the penetrator can be determined. Also the penetrator may be relocated long after deployment, for a period of years, limited essentially by transponder battery capacity.

An acoustic channel having been established, data can be communicated simultaneously with transponder location. The pulse interval form of modulation is chosen because of its inherent power efficiency and flexible dynamic range and because of the simplicity of use with the shipboard line-scan recorder of the profiling system, and because of IOS experience applying it successfully for telemetry from towed nets, dredges and other instruments over the past 15 years. For periods when simultaneous location is not important, it can be preferable to communicate without surface interrogation, the penetrator unit acting instead in a free or 'pinger' mode for the telemetry.

4.2 Transponder design (see also Annex A) For flexibility and reduction of chip count the penetrator transponder/pinger/telemetry unit is designed around a micro-processor, Fig. 1. The acoustic transducer is the most expensive and critical single component and is supplied by Bell Electronics Ltd, using ceramic from ITC Inc. By discussion with BRE it was agreed to multiplex up to 8 channels in the telemetry and to use a 12 bit A/D conversion. The 8 channels can be scanned at long preset intervals, stored and later telemetered. This slow rate of sampling is adequate for all sensors post emplacement, but inadequate for 'transient' sensors required during descent or settlement phases. For this reason the unit has a fast sampling and 'soft' storage mode of

finite preset duration, after which the stored data is replayed at a slower rate suitable for transmission by the acoustic link's pulse interval code.

Software to control the telemetry for various modes of operation has been written and can be assembled to suit individual missions if necessary, for example for different water depths or combinations of sensors. A typical mission might consist of the following:-

State 1 : Steady pinging during descent while sampling at a medium rate until interrupted by bottom detection sensor, initiating:-

State 2 : Fast sampling during deceleration to limit of data storage, followed by

State 3 : Pinger telemetry mode for 60 minutes then, unless receiver interrogated, to

State 4 : 'Asleep', only receiver and threshold circuits powered up, until received interrogation pulse interrupts and powers circuitry into

State 5 : Transponder telemetry, listening between 1.99 and 2.01 secs interval since previous pulse, for as long as interrogations continue. If 9 consecutive pulses are missed unit returns to State 3, then State 4.

Numerical parameters underlined above are preset under software control.

Further information on the transponder software is contained in Annex A, which actually includes work carried out under a DoE contract subsequent to the period of this contract, but relevant for future transponders JRC may require.

4.3 Shipborne System (see also Annex B) The IOS 3.5 kHz reflection profiler is a high resolution system designed to be operated from any research or survey vessel, provided a suitable towing boom is fitted. It consists of four major components: line-scan recorder, transceiver, correlator and towed fish containing a transducer array. The first two are commercially available from Raytheon Ocean Systems Inc. The other two items were designed by IOS because commercial equivalents were found to have inadequate source levels, giving poor results over deep ocean sediments, and were found to have poor towing stability. A long FM swept pulse is generated for transmission and

passes through a matched filter (correlator) on reception. The heavy towed fish design has been used for echo-sounding and other purposes for 20 years and can be towed stably up to 15 knots on its faired armoured cable. The towing boom should have a minimum SWL of 2 tonnes and project around 2 m from either beam, preferably near midships.

Further details can be found in Annex B, of which one copy has been provided in plastic cover sheets and ring binder to form a shipborne manual.

4.4 Sea Trials Three 3.5 kHz, 100 watt transponders were designed, built and mounted in the tail end of 1800 kg BRE penetrators. One was launched from RRS Discovery Cruise 141 in November 1983 and the other two from MS Tyro in March 1984.

4.4.1 Discovery November 1983 Three wire tests were performed in water depths from 4600 m to 5400 m. The transponder replied to the 3.5 kHz profiler down to 2W of transmitted power but continued to transpond erratically on noise during the first wire test. Before the latter two tests the noise performance of the receiver was greatly improved, and the acoustic dynamic range of the acoustic threshold set satisfactorily.

Before the transponder could be mounted in the end of the penetrator the latter had to receive some attention as the thread was tight and somewhat corroded and the 'O' ring face had been damaged by a punch mark.

The penetrator was launched at 1133Z on 9th November but was never heard from again. A recording through the 3.5 kHz profiler fish was later replayed and the penetrator was heard to whine all the way to the bottom; strongly suggesting that the transponder had become damaged, possibly the cavity was acting as a resonator. The double doppler shift between this signal and its bottom echo allowed the terminal velocity to be estimated as 55 m/s ± 2 m/s. This was somewhat higher than the travel time indicated.

4.4.2 M.S. Tyro March 1984 After the failure on Discovery a temporary cowling was quickly designed to take the drag away from the rubber-boot of the transducer.

(i) The first drop This unit was intended to be set to free-ping at 2 Hz for 20 minutes (unfortunately this had to be changed to 50 minutes for test purposes and not changed back). Further work had to be done on the thread and 'O' ring surfaces of the two penetrators to be used before both transponders could be fitted. Mastic tape was wound round the joint in the hope that it would seal any hair-line scratches. The penetrator was launched tail-first and after initial turbulent noise had died away the 2 Hz pings could be seen.

The transponder continued to ping for about 50 minutes and although transmitted to at a 2 second repetition rate, timed out and then repeated the pinging sequence. Eventually, with the transmission rate now at 1 pulse per second, transponding started. By this time the ship had drifted more than 1.5 km from the dropping site. There was no sign of any modulation on the two telemetry signals. Channel 0 carrying the received signal strength was right up against the reference trace as though continually zero.

To judge the range of the transponder the ship steamed off at 5 kts for half an hour. As soon as the engines were restarted the transponder quitted its transponding mode and started free-pinging again. However, the pings could still be seen, through ship's noise, out to about 6 km horizontal range. When the ship had returned to the station and stopped engines, the pings were seen again but drifting erratically. It was two pinging sequences later before transponding started again.

It was possible, by correlating the sub-bottom echoes from the transponder with those from the profiler, to estimate that the penetration depth was about 23 m. Also the rate of approach of the bottom echo on the drop allowed the terminal velocity to be measured as 44 m/s ± 1 m/s. This ties in well with the penetration depth but is about 9 m/s slower than the other penetrators of the same shape. This suggests that the protective cowling was producing a lot of extra drag.

(ii) The second drop Experience from the first drop indicated that the free-pinging was a nuisance so it was written out of the software. The receiver sensitivity was reduced by 12 dB as the first transponder had been too sensitive yet there had been 12 dB more power available from the 3.5 kHz transceiver.

The penetrator was launched but there was no sign of the transponder. During the fall there was the same high level of 'hooting' from the penetrator as had been recorded on Discovery and it is possible that the fate of the transponder was the same.

4.4.3 Discussion Two out of three transponders gave no results at all. What are the likely reasons for these failures?

(1) The one that did work was free-pinging during the descent while the failures were programmed to transpond. However, these two would undoubtedly have replied at random, excited by turbulent and later ship's noise, but did not.

(2) Mechanical damage to the electronics. Heavy components were supported against high accelerations.

(3) Damage to the transducer, flooding or separation of transponder. There is strong evidence for this. Turbulence-generated noise was visible on the 3.5 kHz dry-paper recorder in all three cases; however it was at a lower level in the successful drop, in fact after half a minute the pinging of the transponder could be seen all the way to the bottom as the turbulence noise faded out.

Originally it had been intended to mount the electronics in its own pressure case; later to save this expenditure a decision was made to do away with it and use the penetrator body as the pressure case. Clearly this was a mistake, as it is difficult to obtain the high quality precison finish needed for 'O' ring seals and transducer end cap thread on such a large heavy piece of mild steel.

The lack of wire tests on MS Tyro for whatever reason was a serious omission; tests would have shown up the 50 minute instead of 20 minute pinger state, so the transponder state and direct depth would have been reached much sooner and before the ship had drifted too far away and engines re-started; wire tests might also have indicated any telemetry problems.

Some positive points did emerge from the wire tests on Discovery and the successful drop on Tyro. On both occasions the acoustic signal levels confirmed the calculations that the acoustic link is viable through sediment and ocean. Due to turbulence noise the pinger mode is correct for the drop and engines should be off when interrogating to change to transponder mode.

Opportunities for sea trials cannot often be scheduled when convenient for instrument development. Preparations for Discovery and Tyro tests were both rather rushed; it could turn out that the delay because of industrial action preventing penetrator work on Discovery Cruise 153 in November 1984 may turn out to be helpful giving longer to prepare for the Marion Dufresne cruise in June/July 1985.

For these future penetrator drops the electronics should have its own pressure case, protective transducer shrouds should be better engineered and attached to the penetrator body rather than the transducer end cap, and wire tests must precede deployment.

5. CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER DEVELOPMENT

It is believed that the first objective 2.1 has just about been achieved, but needs further demonstration especially with sensors and telemetry. The second objective 2.2 has not been attempted yet owing to the somewhat hesitant progress in the first. However discussions have begun with industry with a view to sub-contracting production of several units as a prelude to a possible licence to manufacture.

Recently in discussions with JRC staff, methods for possible long term monitoring of a penetrator have been proposed. A moored surface buoy with a hydrophone would pick up the pinger telemetry signals from the penetrator, then decode them into a suitable format for onward radio transmission via the Meteosat satellite communication channel. It is the IOS view that the difficult technical aspects of this approach are (i) the achievement of a reliable long-life deep ocean moored buoy and (ii) the design of an automatic acoustic receiver/decoder. In connection with the latter it should be noted that the present acoustic coding system is optimised for a shipborne receiver based on a line-scan recorder with manual read off. Modifications to the penetrator electronics would be relatively straightforward and the buoy receiver could incorporate signal processing features of the IOS automatic depth tracker (PEST). There are trade-offs between penetrator battery life and the need for error-correcting codes in the acoustic link.

ANNEX A

TRANSPONDER DESIGN

1. INTRODUCTION

Because this project has been a collaborative one with the DoE (BRE) UK, and because work on the design under DoE funding progressed beyond the nominal end of this contract, it was not considered sensible to report on the design as it stood strictly at the end of this JRC contract period, but to describe the design as it exists for future penetrator instrumentation. At the time of writing in fact JRC have ordered further units and they will be provided to the design described here.

2. ORGANISATION OF THE ANNEX

The next section (3) outlines the basic theory including fundamental constraints and chosen compromises, leading to the acoustic method and calculation of parameters. The following section describes briefly the hardware, software and operating procedure including preparation, launch and post penetration telemetry. The detailed design information of software and hardware is provided in the Appendices A1 to A5.

3. THEORY

3.1 System constraints

There are some obvious bounds set by the laws of physics which can be used to define the optimum performance to be aimed for. There are other soft limits imposed by the cost of the system and ship's time, the volume available in the penetrator for instrumentation and batteries and the quality and quantity of the data that is to be transmitted. There are trade-offs and compromises that can be made in the latter case.

Signal to noise ratio

The signal level received by the ship from the transmitter, in 30 to 40 metres of mud and 6000 metres of water, should be higher than the noise in poor weather conditions, i.e. a signal to noise ratio better than 0 dB must be achieved. When transponding is to be used to fix the position of the penetrator the signal to noise level at the transponder must be even higher. The listening conditions at the transducer are considerably better, as deep in the mud there will be a

lower noise background than at the ship where also more power is available for transmission to the transponder.

Operating frequency

In deep water the noise from a variety of sources reaches a minimum in the range 1 to 20 kHz. The actual noise levels are very dependent on the weather conditions, local shipping and particularly self noise from the research ship's main engines and thruster as well as auxiliary equipment. The main source of loss in the acoustic signal path is due to inverse square-law spreading and is frequency independent and inevitable. However, attenuation is frequency dependent, being an exponential function of frequency in both water and mud and very much higher in the latter. It is therefore desirable to use the lowest frequency possible to get a signal through the sediment. Although noise levels will rise with reducing frequency the strongest constraint is set by the physical dimensions of the transducer since as its maximum dimension becomes smaller than a wave-length in water its radiation resistance becomes high and its beam-angle wide. The high radiation resistance, due to poor coupling into the water, means that the transducer can be over stressed either electrically or mechanically before the desired power level can be reached. The wide-beam angle, wasting power in directions other than near vertical can cancel out the benefits of reduced attenuation.

Data encoding

Amplitude and phase modulation of a carrier are impractical in deep water for at least three reasons:-

(1) Signal to noise ratios better than 20 dB are rarely achieved so there would be very limited dynamic range.

(2) Acoustic signals do not travel by simple "line-of-sight" paths but by multiple paths differing by only fractions of a wave-length due to small angle scattering and turbulence. The combination of signals produces randomly varying amplitude and phase distortions.

(3) Reverberation from layers within the sediment and from the water surface interfere with the direct signal, although the effect can in theory be removed if the pattern of echoes is constant or only changing slowly.

Frequency modulation suffers like phase modulation unless frequency shifting is used when the bandwidth required becomes excessive.

Time modulation, using the time delay between two short pulses to carry the information, can be very efficient and can have a large dynamic range. Its disadvantage is that it is slow, though signals can be multiplexed to increase the effective data rate.

Transmission pulse length

The shortest length possible is controlled by the bandwidth of the transducer being approximately equal to the reciprocal of the bandwidth. However, the longer the pulse the better, as it will contain proportionally more energy. If the coding scheme requires pulses to be transmitted in rapid succession then a long pulse would be a limitation specially as additional time must be allowed after each pulse for power amplifier capacitors to recharge. A range of between 2 and 20 msec seems sensible.

Total energy for transmission

This is essentially limited by the volume in the package that can be allocated to batteries. Lithium cells having about twice the energy-density of alkaline cells would make available several megajoules. Note: the kinetic energy of a 1800 kg penetrator at its terminal velocity is of the same order. It has been estimated that AAA alkaline cells would allow up to a megabit of information to be sent.

Listening time

Several hours would be reasonable, but much longer would become expensive in ship's time and increase the risk of losing data due to a worsening of the weather or because the ship has drifted too far off station and must make noise manoeuvring back again.

Resolution

Digital coding say using frequency shift keying could have unlimited resolution by merely extending the number of bits in a sequence but is very expensive in energy. Pulse interval telemetry (P.I.T.) uses only one pulse per data word (plus one reference pulse)

and the resolution is limited only by the maximum time that can be allowed to elapse between the pulses. P.I.T. is, however, a form of analogue modulation and will suffer from timing noise. This will arise from amplitude noise riding on the signal and more important variations in path-length as the receiving "fish" heaves up and down with the swell.

The approximate bit resolution of P.I.T. can be calculated as follows. The rise time t_r of each pulse will be less than half the pulse length, the exact fraction being dependent upon the type and order of the band defining filters used. If the signal pulse voltage into the detector is V_s, the leading edge is rising at V_s/t_r volts per second. In the presence of added noise, V_n rms, the threshold detector time jitter will therefore be $\Delta t = (V_n/V_s)\ t_r$ (rms), assuming that $V_s > 2V_n$ i.e. signal to noise ratio greater than 6 dB. In general this jitter will be present at both reference and signal channel pulses, though uncorrelated, so the time interval jitter will be $\sqrt{2}\ t_r(V_n/V_s)$. If the maximum, or full scale, time interval is t_o, the time interval resolution of the channel is therefore 1 part in $2^{-\frac{1}{2}}(t_o/t_r)(V_s/V_n)$. For the parameters used here, t_o = 2 secs, t_r = 2 msecs, $V_s/V_n > 2$, so the resolution is better than 1 in 1414, i.e. between 10 and 11 bits. The bit rate is thus around 5 bits/second for a single channel. However increasing the number of channels from 1 to N is straightforward, the only decision required concerns whether the pulse intervals for different channels will be allowed to overlap, in which case for (N + 1) pulses transmitted 10N bits equivalent are communicated. In previous underwater applications of P.I.T. overlapping intervals have been allowed and not found to cause undue confusion using a form of direct line scan recorder display. However this feature clearly relies on the recognition of which pulse belongs to which channel at every new frame of pulses.

If the shipborne receiving transducer is heaving at a rate V m/s between the arrival of reference and signal channel pulse, the timing error introduced in addition to the random noise component above is given by (V/C) t_d where C is the sound speed (~1500 m/s) and t_d the signal delay. Generally V will be less than 1.5 m/s, in which case the error amounts to less than 0.1% of the signal.

Transmission and bottom reverberation

If transponding is used to synchronise data transmissions then the surface reverberation of the pulse sent from the ship and its bottom and sub-bottom echoes appear mixed in with the data pulses. This interference can be reduced by separating the transmitter and receiving hydrophone, by cutting down the power transmitted or more effectively by designing the telemetry system to send data up at its own rate (free-pinging) controlled by a local crystal oscillator.

Singing round

This can occur during transponding if the transponder responds to the echo of one of its earlier transmissions. In certain critical water depths, when the round trip time for the echo is a multiple of the repetition period, a permanent oscillation can be set up. This problem can usually be avoided by making the transponder receiver not sufficiently sensitive to hear its own echoes and by arranging that it listens in the narrow time window surrounding the expected interrogation pulse arrival time.

Two or more transponders in the area could interfere with each other in a more complex way.

Pulse repetition rate

If pulse interval telemetry is used then the desired resolution sets the fastest rate and there seems to be no good reason for using a slower rate as it would increase the time taken to receive all the data.

Timing of sampling

Certain sensors, particularly accelerometers, are likely to be affected by acoustic pick-up during transmissions. There is also the probability of electrical interference to sensitive sensor processing circuitry at the same time. Sampling must either be synchronised with the quiet periods during a transmission sequence or performed in a different phase and logged for later transmission.

3.2 The selected parameters

3.5 kHz was selected for the operating frequency being the lowest frequency for which a practical transducer could be designed and also

the frequency already used by IOS for sub-bottom profiling. The transducer designed for this job had a bandwidth of about 400 Hz. Allowing for the spread between different units, the choice of 200 Hz as the design bandwidth seemed reasonable. This sets the minimum pulse length to 5 ms and this was adopted.

After due consideration free-pinging pulse interval telemetry was chosen to transmit the logged data. One of the benefits of this type of transmission is that if the signal is received on a synchronously swept dry-paper recorder a graphical display is produced without any processing other than amplification and filtering.

The power amplifier was built to provide 100 watts of acoustic power consuming about 200 watts in the process. The energy taken from batteries to produce a 5 ms pulse was thus 1 joule.

The receiver was designed with a bandwidth of 200 Hz and automatic gain control so that the triggering threshold would adjust itself to suit the received signal level while remaining too insensitive to allow sing-round.

It was decided to use a 2 second repetition rate and multiplex a number of data channels by scaling and offsetting each one individually. Thus it would be possible in say an hour to transmit 1800 samples in each of 5 channels with a resolution of 10 bits.

3.3 Sonar calculations

Assuming:-

Operating frequency	= 3.5 kHz
Water depth	= 6000 m
Penetration depth	= 35 m
Attenuation in mud	= 0.1 dB/m-kHz
	= 12 dB one way
Power of ship's system	= 2 Kw
with directivity index	= 10 dB
Power of telemetry system	= 100 W
with directivity index	= 5 dB
and with 5 msec pulse, bandwidth	= 200 Hz
Sea-state 6 noise in 200 Hz bandwidth	= -42 dB re Pa

(1) Sound pressure level at transducer

Fish source level	= 33 dB re 1 watt
+ 50.8 dB re 1 watt/Pa @ 1 metre	= 83.8
+ 10 dB directivity index	= 94 dB re Pa
Losses:	
Spreading loss over 6000 m	= 75.6 dB
Water attenuation (@ 0.25 dB/km)	= 1.5 dB
Scattering loss	= 3.0 dB
Loss due to acoustic impedance mismatch at the bottom	= 1.0 dB
Attenuation through sediment	= 12 dB
Total	= 93 dB
Thus sound pressure level at transducer	= 1 dB re Pa

(2) Sound pressure level at the ship

Transducer source level	= 20 dB re 1 watt
+ 50.8 dB re 1 watt/Pa @ 1 metre	= 70.8
+ 5 dB directivity index	= 76 dB
With the same losses the level at the surface will be	= -17 dB re Pa

This is about the same level as the profiler's bottom echo assuming 30% reflectance.

(3) Sing-round level at transponder

The total losses will be greater by 6 dB because of the double path plus

the remaining losses repeated	= 93 dB
Extra distance	= +6
Other water losses	= +5.5
Mud attenuation	= +12
Total	= 116.5 dB

With a transponder source level of 76 dB re Pa the sound pressure level back at the transponder will be = -40.5 dB re Pa

About 40 dB below the expected level from the ship. This assumes 100% reflection at the surface.

(4) Noise level at transducer
The level near the surface will be about -42 dB re Pa and there will be a few dBs drop in the water-column due to attenuation, scattering and refraction. It is expected that the noise will receive a similar attenuation in the mud, as the signal. Allowing 15 dB for these losses
Noise level at transducer = -57 dB re Pa
Ship's noise could, however, add considerably to this.

(5) Transducer receiving sensitivity
at 1 m on axis = -95 dB re 1V/Pa

4. SYSTEM DESCRIPTION

4.1 Hardware (see Fig. 1)

4.1.1 The transducer

This is a commercially produced item using a piezo-electric ring mounted off from a base-plate and surrounded by a rubber boot filled with oil. The base-plate carries a thread and 'O' ring seal compatible with an I.O.S. designed pressure case.

One of the disadvantages of a ring transducer is that the electro-acoustic coupling is poor and this both raises the impedance seen into the electrical terminals and narrows the bandwidth. Limits are thus imposed on the maximum power that can be transmitted and the form of modulation that can be used.

4.1.2 The pressure case

Earlier plans to use the penetrator as a pressure case were discarded due to the difficulty of machining a heavy penetrator to the necessary precision. A standard 6 inch outside diameter 30 inch long tube takes the transducer at one end and at the other, an end plate with 16 electrical connections via underwater plugs.

4.1.3 The circuitry (see Appendix A6)

One long printed circuit board carries a low power microprocessor and support chips, a daughter board of additional random access memory

where data are logged and the analogue components. The analogue and digital elements of the board are deliberately separated to reduce mutual interference.

The analogue part comprises:-

(i) The transmitter. Essentially this is two power transistors driven through a buffer from the microprocessor and coupled through an output transformer to the transducer via a tuning choke.

(ii) The receiver. A signal from the transducer is extracted by a tertiary winding on the output transformer through a matched pad. The matched pad prevents the transmitter being loaded down by the receiver during transmission but ensures that maximum power is absorbed from the transducer on reception. The signal is amplified up by a low-noise first stage and two band-pass filter stages with a gain controlled stage between them. Detection is approximately square-law in the region of 50 mV, the switching point of the following comparator. The output from this is sharpened up to provide a negative logic signal to interrupt the microprocessor.

(iii) The analogue to digital converter. One of 8 (expandable to 16) analogue signals between +5 and -5 volts are selected by a multiplexer for digitising. During conversion the signal is held steady by the sample and hold circuit. 12 bits are converted in about 30 microseconds.

(iv) The supply switch. Transistors are used to control the +12 and -12 volt supplies to off-board sensor conditioning circuitry to allow them to be switched off to conserve power between samples at low sampling rates.

The digital part of the board consists of a HD6303 microprocessor that can address 16K of read-only-memory (ROM) and up to 40K of static random-access-memory (SRAM), controls the analogue to digital converter and generates pulses to drive the transmitter.

4.2 Software (see Fig. 2 and Appendices A1-A5)

A 'tuned' version of the FORTH language is resident in one 8K ROM. This also contains an editor, driver routines for an external bubble memory and an elementary monitor program. A further 8K of ROM has the compiled procedures which constitute PATSY, the run-time program, that samples, logs and transmits data using P.I.T.

FORTH plus PATSY can be viewed as a dictionary of procedures or 'words' on to the end of which additional words may be compiled at any time. This allows the user, through a standard terminal and interfacing box, to create test routines at the last minute to, for instance, check the calibration and correct functioning of sensors and test the memory used for data storage. It is even possible in an emergency to recompile a new version of the main program without the use of a development system and produce code that will execute immediately and at full operational speed.

4.3 Sampling and data transmission sequence

This is the description of a typical sequence.

4.3.1 Preparation

After test and diagnostics have been run the user can preset a number of parameters such as the number cycles of sampling or transmission of different data sets and the scaling to be applied to each channel for transmission. To reduce the work-load these parameters can be given default values by executing SETUP and then only alterations need be made. The main program can then be executed triggering a series of pings at one a minute. The terminal can now be disconnected and the electronics sealed into its pressure case.

The optical-switch used to sense the instant of contact with the sediment is also used to inform the computer of the instant of launch by the removal of a shutter blocking the optical path. Ten seconds after the shutter is initially introduced this is acknowledged by the ping rate changing to once every ten seconds. (Because the telemetry system and sensor package must be connected to each other before the optical switch can be connected, a shorting plug must be substituted for the optical switch, i.e. the unconnected optical switch is equivalent to a connected but blocked switch. The exchange of the lead from shorting plug to optical switch must then be performed within 10 seconds). It is hoped that this cumbersome procedure can be eliminated in the future.

4.3.2 Descent through the water-column

As the penetrator is released and the optical switch unblocked PHASE1 sampling starts. Sampling of tilt, temperature and

acceleration proceeds at 10 Hz interleaved with pinging at the same frequency. These medium sampled data values are stored for later transmission. Meanwhile two accelerometers are sampled at 500 Hz and stored in a rolling-buffer. One minute into the fall the optical switch is enabled to interrupt on contact with the sediment.

4.3.3 Deceleration through the sediment

This, PHASE2, of the sampling is instigated by an interrupt from the optical switch or, as a backup, by the deceleration signals exceeding a threshold. PHASE2 is similar to PHASE1 except that it times-out after 2 seconds and no pings are transmitted.

4.3.4 Transmission of resting attitude

This is a live transmission using free running pinging at 1/2 Hz repetition rate of tilt and accelerometer signals for a few minutes.

4.3.5 First transponding session

Ten minutes of transponding at this time, before the ship has had a chance to drift away, allows the penetration depth of the transducer to be determined acoustically. (Doppler shift imposed on the 10 Hz pinging during the fall through the water-column also allows the terminal velocity to be calculated).

4.3.6 Logged data transmissions

The fast rate (500 Hz) data that has been sampled into rolling-buffers is backed up to a point 1/2 second before deceleration commenced and is copied into other buffers before being transmitted by free running P.I.T. The medium rate (10 Hz) data sampled through the water-column follows similarly encoded. This sequence is not in the correct temporal order but it is considered desirable to transmit the more important fast rate data first before anything can go wrong. It might help the immediate interpretation of the logged data if the samples in each batch were transmitted in reverse order.

4.3.7 Second transponding session

By the time the complete logged data set has been sent 1 to 2 hours will have passed during which the ship can have drifted several miles from the launch site. A suitable period of transponding at this stage will allow the penetrator's position to be fixed and for the

ship to manoeuvre back to a point overhead.

4.3.8 Second session of live pinging

This is a good opportunity, for 5 to 10 minutes, to find out whether the attitude of the penetrator has changed and to get a stable temperature measurement in case temperature compensation needs to be applied to any of the data.

4.3.9 Logged data transmission with JRC format

One of the accelerometer channels is retransmitted with a different format to provide data for tests on the Meteosat transceiver.

4.3.10 The end

Rather than simply stopping the program it might as well repeat itself indefinitely by looping back to transmit the fast data again (Section 4.3.5).

In future it may be required that after several repetitions of the logged data the telemetry system should reduce power consumption to a minimum and sample and log data at a slow rate over months or years and come fully awake to transmit that data on demand.

FIGURE 1

SYSTEM FLOW CHART

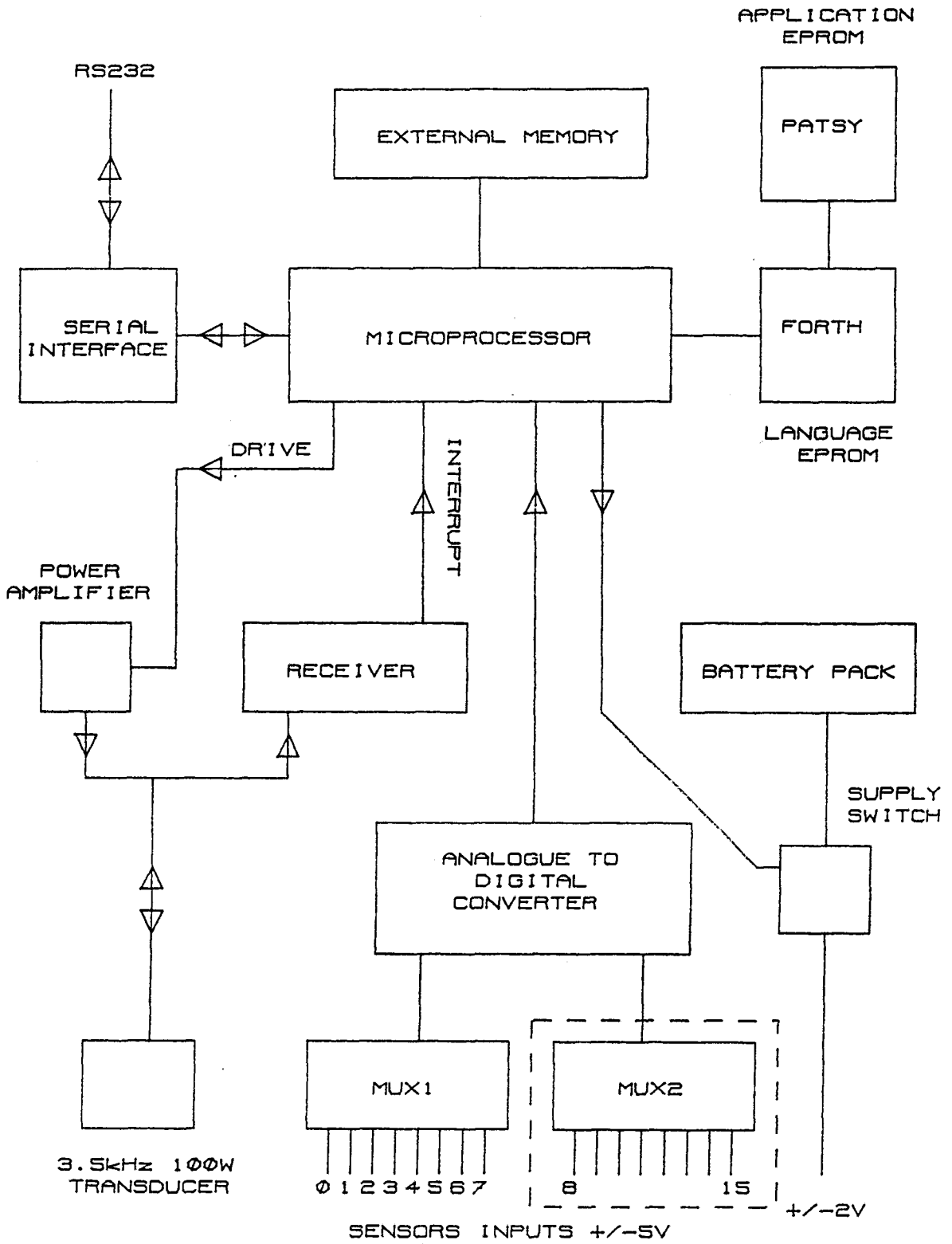

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FIGURE 2

MEMORY MAP

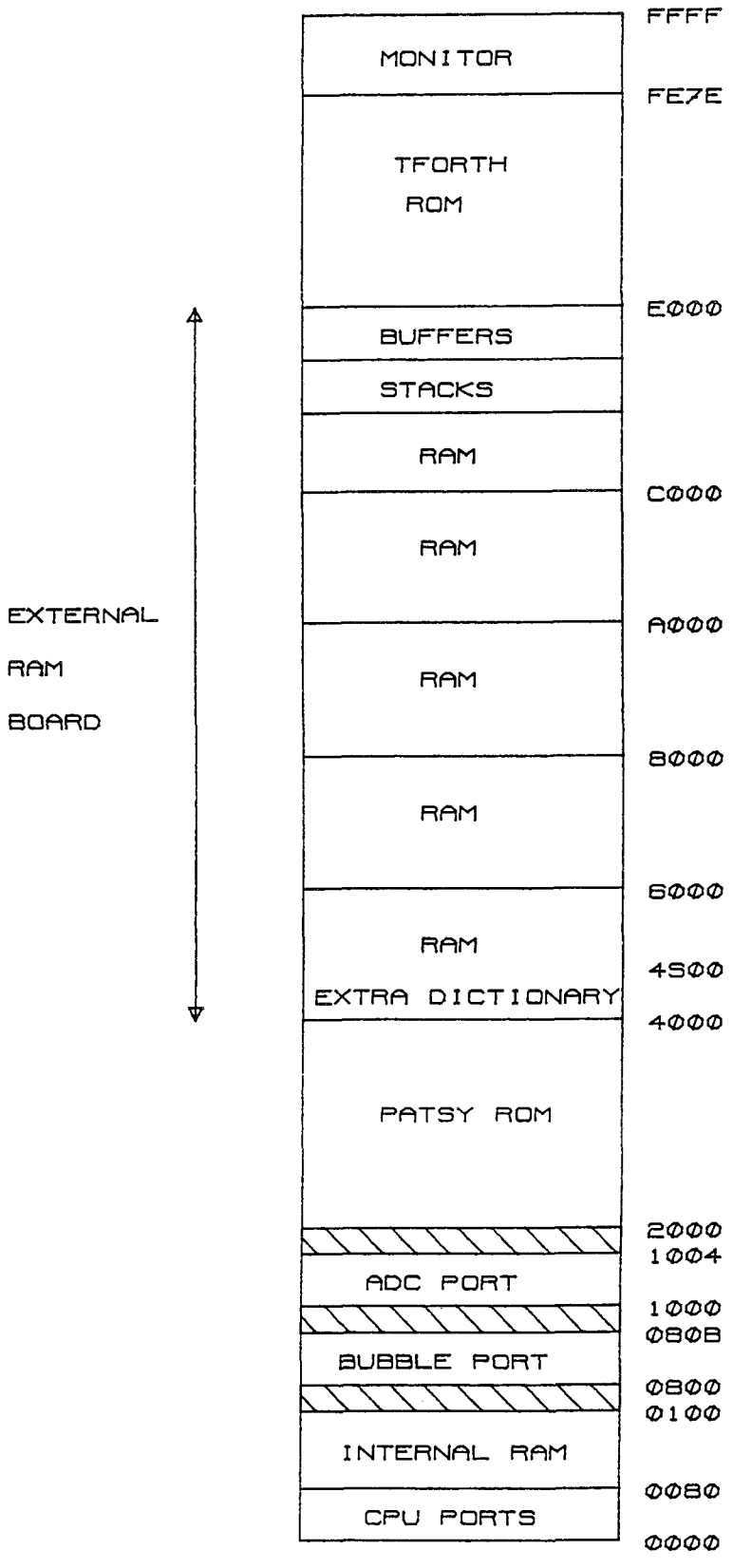
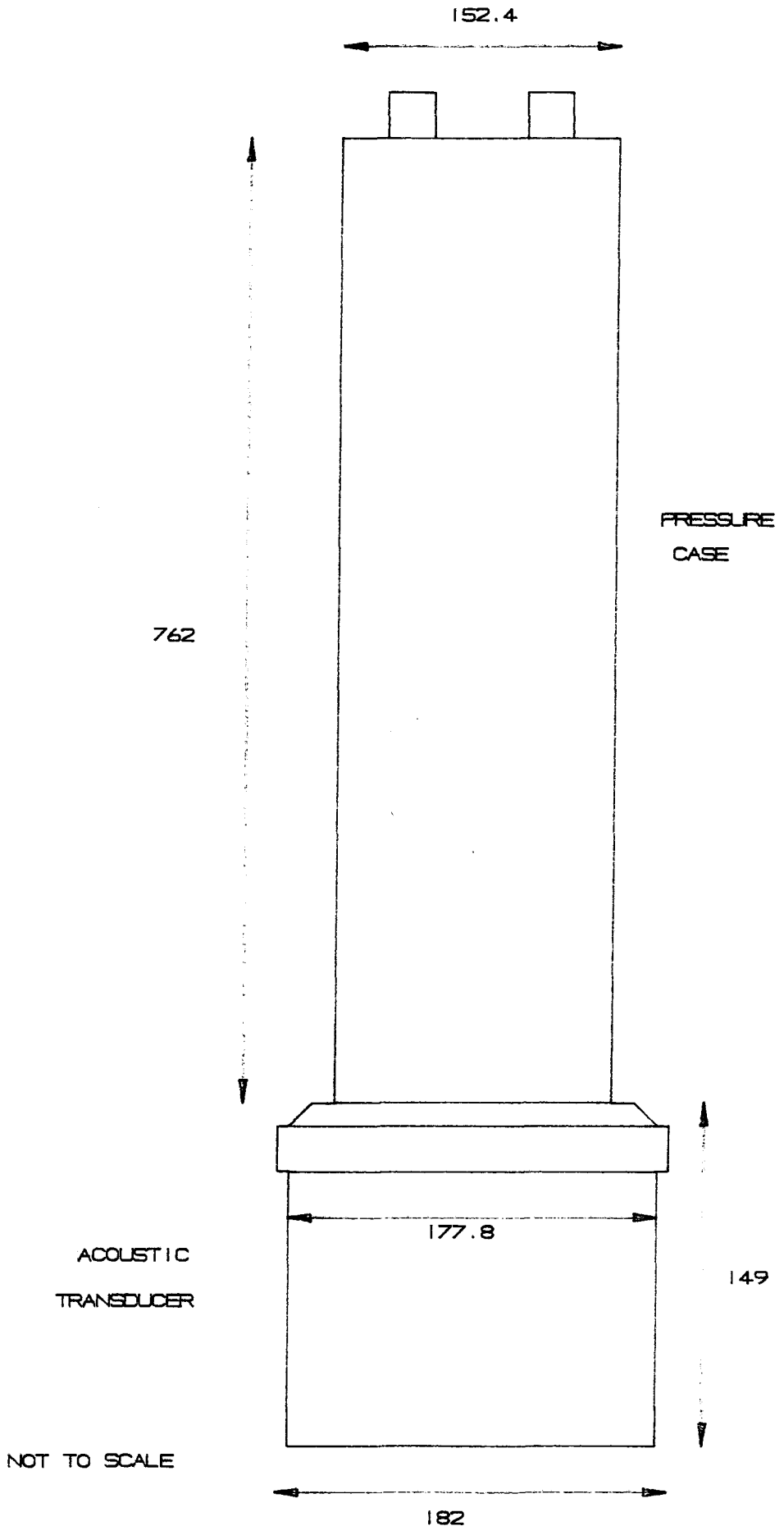


FIGURE 3

TELEMETRY SYSTEM OUTLINE



APPENDIX A1 TFORTH ASSEMBLY LISTING

FORTH SSB MNEMONIC ASSEMBLER PAGE 1

```
                     1:          NAM    FORTH
                     2: * FILENAME "FORTH1.SRC"
                     3: * TURBO FORTH FOR PENETRATOR
                     4: * STARTING IN ROM AT $E000
                     5: *
0008                 6: NBLK     EQU    8
E000                 7: MEMEND   EQU    68*NBLK+$DDE0
DFFF                 8: MEMTOP   EQU    $DFFF
0011                 9: ACIAC    EQU    $11
0012                10: ACIAD    EQU    $12
                    11: *
0080                12:          ORG    $80
0080                13: MUDFLG   RMB    2
0082                14: HLFCYC   RMB    2
0084                15: OVRFWS   RMB    2
0086                16: SIGFLG   RMB    2
0088                17: DWNCNT   RMB    2
                    18: *
                    19: * INTERRUPT VECTORS
00D0                20:          ORG    $D0
00D0 7E FF95        21: SCI      JMP    TRAP        serial interrupt
00D3 7E FF95        22: TOF      JMP    TRAP        Timer over-flow interrupt
00D6 7E FF95        23: OCF      JMP    TRAP        Output compare interrupt
00D9 7E FF95        24: ICF      JMP    TRAP        Input capture interrupt
00DC 7E FF95        25: IRQ1     JMP    TRAP        PIA interrupts.
                    26: *
00E0                27:          ORG    $E0
00E0                28: N        RMB    10
00EA                29:          RMB    6
00F0                30: XTEMP    RMB    2
00F2                31: UP       RMB    2
                    32: *
2000                33:          ORG    $2000
                    34: *
2000 C5             35:          FCB    $C5
2001 46             36:          FCC    "FORT"
2002 4F 52
2004 54
2005 C8             37:          FCB    $C8
2006 FD D0          38:          FDB    NOOP-7
2008 BD E9C5        39: FORTH    JSR    DODOES
200B 7E EFD2        40:          JMP    DOVOC
200E 81 A0          41:          FDB    $81A0
2010 20 2D          42:          FDB    TASK-7
2012 00 00          43:          FDB    0
2014 54             44:          FCC    "Turbo-forth for 6303 1984"
2015 75 72
2017 62 6F
2019 2D 66
201B 6F 72
201D 74 68
201F 20 66
2021 6F 72
2023 20 36
2025 33 30
2027 33 20
2029 31 39
202B 38 34
202D 84             45:          FCB    $84
```

FORTH SSB MNEMONIC ASSEMBLER PAGE 2

```
202E 54          46:          FCC    "TAS"
202F 41 53
2031 CB          47:          FCB    $CB
2032 20 00       48:          FDB    FORTH-8
2034 39          49: TASK     RTS
2035             50: REND     EQU    *
                 51: *
4000             52:          ORG    $4000
4000             53: UORIG    RMB    6
4006             54: XSPZER   RMB    2
4008             55: XRZERO   RMB    2
400A             56: XTIB     RMB    2
400C             57: XWIDTH   RMB    2
400E             58: XWARN    RMB    2
4010             59: XFENCE   RMB    2
4012             60: XDP      RMB    2
4014             61: XVOCL    RMB    2
4016             62: XBLK     RMB    2
4018             63: XIN      RMB    2
401A             64: XOUT     RMB    2
401C             65: XSCR     RMB    2
401E             66: XOFSET   RMB    2
4020             67: XCONT    RMB    2
4022             68: XCURR    RMB    2
4024             69: XSTATE   RMB    2
4026             70: XBASE    RMB    2
4028             71: XDPL     RMB    2
402A             72: XFLD     RMB    2
402C             73: XCSP     RMB    2
402E             74: XRNUM    RMB    2
4030             75: XHLD     RMB    2
4032             76: XDELAY   RMB    2
4034             77: XCOLUM   RMB    2
4036             78: IOSTAT   RMB    2
4038             79:          RMB    8
4040             80: XUSE     RMB    2
4042             81: XPREV    RMB    2
4044             82:          RMB    4
                 83: *
E000             84:          ORG    $E000
E000 01          85: ORIG     NOP
E001 7E F081     86:          JMP    CENT
E004 01          87:          NOP
E005 7E F0C9     88:          JMP    WENT
E008 18 9F       89:          FDB    6303,0002
E00A 00 02
E00C 00 00       90:          FDB    0
E00E 00 7F       91: BACKSP   FDB    $7F
E010 40 00       92: UPINIT   FDB    UORIG
E012 DC FE       93: SINIT    FDB    $DCFE
E014 DD DF       94: RINIT    FDB    $DDDF
E016 DD 00       95:          FDB    $DD00
E018 00 1F       96:          FDB    31
E01A 00 01       97:          FDB    1
E01C 20 35       98: FENCIN   FDB    REND
E01E 40 48       99: DPINIT   FDB    UORIG+$48
E020 20 08      100: VOCINT   FDB    FORTH
E022 00 64      101: COLINT   FDB    100
E024 00 00      102: DELINT   FDB    0
                103: *
```

FORTH SSB MNEMONIC ASSEMBLER PAGE 3

```
E026 83        104:          FCB   $83
E027 4C        105:          FCC   "LI"
E028 49
E029 D4        106:          FCB   $D4
E02A 00 00     107:          FDB   0
E02C DF F0     108: LIT      STX   XTEMP
E02E 38        109:          FCB   $38          PULX
E02F EC 00     110:          FDB   $EC00        LDD 0,X
E031 08        111:          INX
E032 08        112:          INX
E033 3C        113:          FCB   $3C          PSHX
E034 DE F0     114:          LDX   XTEMP
E036 ED 00     115:          FDB   $ED00        STD 0,X
E038 09        116:          DEX
E039 09        117:          DEX
E03A 39        118:          RTS
               119: *
E03B 86        120:          FCB   $86
E03C 43        121:          FCC   "CLITE"
E03D 4C 49
E03F 54 45
E041 D2        122:          FCB   $D2
E042 E0 26     123:          FDB   LIT-6
E044 DF F0     124: CLITER   STX   XTEMP
E046 38        125:          FCB   $38          PULX
E047 4F        126:          CLR A
E048 E6 00     127:          LDA B 0,X
E04A 08        128:          INX
E04B 3C        129:          FCB   $3C          PSHX
E04C DE F0     130:          LDX   XTEMP
E04E ED 00     131:          FDB   $ED00        STD 0,X
E050 09        132:          DEX
E051 09        133:          DEX
E052 39        134:          RTS
               135: *
E053 87        136:          FCB   $87
E054 45        137:          FCC   "EXECUT"
E055 58 45
E057 43 55
E059 54
E05A C5        138:          FCB   $C5
E05B E0 3B     139:          FDB   CLITER-9
E05D EC 02     140: EXEC     FDB   $EC02        LDD 2,X
E05F 08        141:          INX
E060 08        142:          INX
E061 37        143:          PSH B
E062 36        144:          PSH A
E063 39        145:          RTS
               146: *
E064 87        147:          FCB   $87
E065 30        148:          FCC   "0BRANC"
E066 42 52
E068 41 4E
E06A 43
E06B C8        149:          FCB   $C8
E06C E0 53     150:          FDB   EXEC-10
E06E 08        151: ZBRAN    INX
E06F 08        152:          INX
E070 EC 00     153:          FDB   $EC00        LDD 0,X
E072 39        154:          RTS
```

FORTH SSB MNEMONIC ASSEMBLER PAGE 4

```
                    155: *
E073 86             156:          FCB   $86
E074 28             157:          FCC   "(LOOP"
E075 4C 4F
E077 4F 50
E079 A9             158:          FCB   $A9
E07A E0 64          159:          FDB   ZBRAN-10
E07C 4F             160: XLOOP    CLR A
E07D C6 01          161:          LDA B #1
E07F 20 0E          162:          BRA   XPLOP2
                    163: *
E081 87             164:          FCB   $87
E082 28             165:          FCC   "(+LOOP"
E083 2B 4C
E085 4F 4F
E087 50
E088 A9             166:          FCB   $A9
E089 E0 73          167:          FDB   XLOOP-9
E08B 08             168: XPLOOP   INX
E08C 08             169:          INX
E08D EC 00          170:          FDB   $EC00       LDD 0,X
E08F DF F0          171: XPLOP2   STX   XTEMP
E091 4D             172:          TST A
E092 2A 11          173:          BPL   XPLOF
E094 8D 09          174:          BSR   XPLOPS
E096 0D             175:          SEC
E097 E2 07          176:          SBC B 7,X
E099 A2 06          177:          SBC A 6,X
E09B 2A 19          178:          BPL   ZBYES
E09D 20 0C          179:          BRA   XPLONO
E09F 30             180: XPLOPS   TSX
E0A0 E3 04          181:          FDB   $E304       ADD D 4,X
E0A2 ED 04          182:          FDB   $ED04       STD 4,X
E0A4 39             183:          RTS
E0A5 8D F8          184: XPLOF    BSR   XPLOPS
E0A7 A3 06          185:          FDB   $A306       SUB D 6,X
E0A9 2B 0B          186:          BMI   ZBYES
E0AB 38             187: XPLONO   FCB   $38         PULX
E0AC 31             188:          INS
E0AD 31             189:          INS
E0AE 31             190:          INS
E0AF 31             191:          INS
E0B0 3C             192:          FCB   $3C         PSHX
E0B1 DE F0          193:          LDX   XTEMP
E0B3 86 01          194:          LDA A #1
E0B5 39             195:          RTS
E0B6 DE F0          196: ZBYES    LDX   XTEMP
E0B8 4F             197:          CLR A
E0B9 39             198:          RTS
                    199: *
E0BA 84             200:          FCB   $84
E0BB 28             201:          FCC   "(DO"
E0BC 44 4F
E0BE A9             202:          FCB   $A9
E0BF E0 81          203:          FDB   XPLOOP-10
E0C1 32             204: XDO      PUL A
E0C2 33             205:          PUL B
E0C3 DD             206:          FCB   $DD,XTEMP   STD XTEMP
E0C4 F0
E0C5 08             207:          INX
```

FORTH SSB MNEMONIC ASSEMBLER PAGE 5

```
E0C6 08       208:          INX
E0C7 EC 02    209:          FDB   $EC02        LDD 2,X
E0C9 37       210:          PSH B
E0CA 36       211:          PSH A
E0CB EC 00    212:          FDB   $EC00        LDD 0,X
E0CD 37       213:          PSH B
E0CE 36       214:          PSH A
E0CF 08       215:          INX
E0D0 08       216:          INX
E0D1 DC       217:          FCB   $DC,XTEMP    LDD XTEMP
E0D2 F0
E0D3 37       218:          PSH B
E0D4 36       219:          PSH A
E0D5 39       220:          RTS
              221: *
E0D6 81       222:          FCB   $81
E0D7 C9       223:          FCB   $C9
E0D8 E0 BA    224:          FDB   XD0-7
E0DA DF F0    225: I        STX   XTEMP
E0DC 30       226:          TSX
E0DD EC 02    227:          FDB   $EC02        LDD 2,X
E0DF DE F0    228:          LDX   XTEMP
E0E1 ED 00    229:          FDB   $ED00        STD 0,X
E0E3 09       230:          DEX
E0E4 09       231:          DEX
E0E5 39       232:          RTS
              233: *
E0E6 85       234:          FCB   $85
E0E7 44       235:          FCC   "DIGI"
E0E8 49 47
E0EA 49
E0EB D4       236:          FCB   $D4
E0EC E0 D6    237:          FDB   I-4
E0EE A6 05    238: DIGIT    LDA A 5,X
E0F0 80 30    239:          SUB A #$30
E0F2 2B 19    240:          BMI   DIGIT2
E0F4 81 0A    241:          CMP A #$A
E0F6 2B 0A    242:          BMI   DIGIT0
E0F8 81 11    243:          CMP A #$11
E0FA 2B 11    244:          BMI   DIGIT2
E0FC 81 2B    245:          CMP A #$2B
E0FE 2A 0D    246:          BPL   DIGIT2
E100 80 07    247:          SUB A #7
E102 A1 03    248: DIGIT0   CMP A 3,X
E104 2A 07    249:          BPL   DIGIT2
E106 C6 01    250:          LDA B #1
E108 A7 05    251:          STA A 5,X
E10A E7 03    252: DIGIT1   STA B 3,X
E10C 39       253:          RTS
E10D 5F       254: DIGIT2   CLR B
E10E 08       255:          INX
E10F 08       256:          INX
E110 E7 02    257:          STA B 2,X
E112 20 F6    258:          BRA   DIGIT1
              259: *
E114 86       260:          FCB   $86
E115 28       261:          FCC   "(FIND"
E116 46 49
E118 4E 44
E11A A9       262:          FCB   $A9
```

FORTH SSB MNEMONIC ASSEMBLER PAGE 6

```
E11B E0 E6     263:          FDB   DIGIT-8
E11D 08        264: PFIND    INX
E11E 08        265:          INX
E11F EC 00     266:          FDB   $EC00        LDD 0,X
E121 DD        267:          FCB   $DD,N        STD N
E122 E0
E123 EC 02     268:          FDB   $EC02        LDD 2,X
E125 DD        269:          FCB   $DD,N+2      STD N+2
E126 E2
E127 DF F0     270:          STX   XTEMP
E129 DE E0     271:          LDX   N
E12B E6 00     272: PFIND1   LDA B 0,X
E12D D7 E6     273:          STA B N+6
E12F C4 3F     274:          AND B #$3F
E131 08        275:          INX
E132 DF E0     276:          STX   N
E134 DE E2     277:          LDX   N+2
E136 A6 00     278:          LDA A 0,X
E138 08        279:          INX
E139 DF E4     280:          STX   N+4
E13B 11        281:          CBA
E13C 26 24     282:          BNE   PFIND4
E13E DE E4     283: PFIND2   LDX   N+4
E140 A6 00     284:          LDA A 0,X
E142 08        285:          INX
E143 DF E4     286:          STX   N+4
E145 DE E0     287:          LDX   N
E147 E6 00     288:          LDA B 0,X
E149 08        289:          INX
E14A DF E0     290:          STX   N
E14C 5D        291:          TST B
E14D 2A 10     292:          BPL   PFIND8
E14F C4 7F     293:          AND B #$7F
E151 11        294:          CBA
E152 27 17     295:          BEQ   FOUND
E154 EE 00     296: PFIND3   LDX   0,X
E156 26 D3     297:          BNE   PFIND1
E158 DE F0     298:          LDX   XTEMP
E15A 4F        299:          CLR A
E15B 5F        300:          CLR B
E15C ED 02     301:          FDB   $ED02        STD 2,X
E15E 39        302:          RTS
E15F 11        303: PFIND8   CBA
E160 27 DC     304:          BEQ   PFIND2
E162 DE E0     305: PFIND4   LDX   N
E164 E6 00     306: PFIND9   LDA B 0,X
E166 08        307:          INX
E167 2A FB     308:          BPL   PFIND9
E169 20 E9     309:          BRA   PFIND3
E16B DE F0     310: FOUND    LDX   XTEMP
E16D DC        311:          FCB   $DC,N        LDD N
E16E E0
E16F C3        312:          FCB   $C3          ADD D #
E170 00 02     313:          FDB   2
E172 ED 02     314:          FDB   $ED02        STD 2,X
E174 09        315:          DEX
E175 09        316:          DEX
E176 09        317:          DEX
E177 09        318:          DEX
E178 D6 E6     319:          LDA B N+6
```

```
FORTH                                          SSB MNEMONIC ASSEMBLER  PAGE 7

E17A 4F          320:          CLR A
E17B ED 04       321:          FDB   $ED04       STD 4,X
E17D ED 02       322:          FDB   $ED02       STD 2,X
E17F 39          323:          RTS
                 324: *
E180 87          325:          FCB   $87
E181 45          326:          FCC   "ENCLOS"
E182 4E 43
E184 4C 4F
E186 53
E187 C5          327:          FCB   $C5
E188 E1 14       328:          FDB   PFIND-9
E18A E6 03       329: ENCLOS   LDA B 3,X
E18C DF F0       330:          STX   XTEMP
E18E EE 04       331:          LDX   4,X
E190 7F 00E0     332:          CLR   N
E193 A6 00       333: ENCL2    LDA A 0,X
E195 27 1F       334:          BEQ   ENCL6
E197 11          335:          CBA
E198 26 06       336:          BNE   ENCL3
E19A 08          337:          INX
E19B 7C 00E0     338:          INC   N
E19E 20 F3       339:          BRA   ENCL2
E1A0 96 E0       340: ENCL3    LDA A N
E1A2 36          341:          PSH A
E1A3 A6 00       342: ENCL4    LDA A 0,X
E1A5 27 15       343:          BEQ   ENCL7
E1A7 11          344:          CBA
E1A8 27 06       345:          BEQ   ENCL5
E1AA 08          346:          INX
E1AB 7C 00E0     347:          INC   N
E1AE 20 F3       348:          BRA   ENCL4
E1B0 D6 E0       349: ENCL5    LDA B N
E1B2 17          350:          TBA
E1B3 4C          351:          INC A
E1B4 20 0A       352:          BRA   ENCL8
E1B6 D6 E0       353: ENCL6    LDA B N
E1B8 37          354:          PSH B
E1B9 5C          355:          INC B
E1BA 20 02       356:          BRA   ENCL7+2
E1BC D6 E0       357: ENCL7    LDA B N
E1BE 96 E0       358:          LDA A N
E1C0 DE F0       359: ENCL8    LDX   XTEMP
E1C2 09          360:          DEX
E1C3 09          361:          DEX
E1C4 09          362:          DEX
E1C5 09          363:          DEX
E1C6 A7 03       364:          STA A 3,X
E1C8 E7 05       365:          STA B 5,X
E1CA 32          366:          PUL A
E1CB A7 07       367:          STA A 7,X
E1CD 4F          368:          CLR A
E1CE A7 02       369:          STA A 2,X
E1D0 A7 04       370:          STA A 4,X
E1D2 A7 06       371:          STA A 6,X
E1D4 39          372:          RTS
                 373: *
E1D5 84          374:          FCB   $84
E1D6 45          375:          FCC   "EMI"
E1D7 4D 49
```

FORTH SSB MNEMONIC ASSEMBLER PAGE 8

```
E1D9 D4          376:          FCB   $D4
E1DA E1 80       377:          FDB   ENCLOS-10
E1DC A6 03       378: EMIT     LDA A 3,X
E1DE 08          379:          INX
E1DF 08          380:          INX
E1E0 DF F0       381:          STX   XTEMP
E1E2 BD F481     382:          JSR . PEMIT
E1E5 DE F2       383:          LDX   UP
E1E7 6C 1B       384:          INC   XOUT+1-UORIG,X
E1E9 26 02       385:          BNE   *+4
E1EB 6C 1A       386:          INC   XOUT-UORIG,X
E1ED DE F0       387:          LDX   XTEMP
E1EF 39          388:          RTS
                 389: *
E1F0 83          390:          FCB   $83
E1F1 4B          391:          FCC   "KE"
E1F2 45
E1F3 D9          392:          FCB   $D9
E1F4 E1 D5       393:          FDB   EMIT-7
E1F6 DF F0       394: KEY      STX   XTEMP
E1F8 BD F49B     395:          JSR   PKEY
E1FB DE F0       396: KEY1     LDX   XTEMP
E1FD 09          397:          DEX
E1FE 09          398:          DEX
E1FF A7 03       399:          STA A 3,X
E201 4F          400:          CLR A
E202 A7 02       401:          STA A 2,X
E204 39          402:          RTS
                 403: *
E205 89          404:          FCB   $89
E206 3F          405:          FCC   "?TERMINA"
E207 54 45
E209 52 4D
E20B 49 4E
E20D 41
E20E CC          406:          FCB   $CC
E20F E1 F0       407:          FDB   KEY-6
E211 DF F0       408: QTERM    STX   XTEMP
E213 BD F4B1     409:          JSR   PQTER
E216 20 E3       410:          BRA   KEY1
                 411: *
E218 82          412:          FCB   $82
E219 43          413:          FCC   "C"
E21A D2          414:          FCB   $D2
E21B E2 05       415:          FDB   QTERM-12
E21D DF F0       416: CR       STX   XTEMP
E21F BD F4BC     417:          JSR   PCR
E222 DE F0       418:          LDX   XTEMP
E224 39          419:          RTS
                 420: *
E225 85          421:          FCB   $85
E226 43          422:          FCC   "CMOV"
E227 4D 4F
E229 56
E22A C5          423:          FCB   $C5
E22B E2 18       424:          FDB   CR-5
E22D EC 02       425: CMOVE    FDB   $EC02       LDD 2,X
E22F DD          426:          FCB   $DD,N       STD N
E230 E0
E231 08          427:          INX
```

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```
E232 08       428:          INX
E233 EC 02    429:          FDB   $EC02       LDD 2,X
E235 DD       430:          FCB   $DD,N+2     STD N+2
E236 E2
E237 08       431:          INX
E238 08       432:          INX
E239 EC 02    433:          FDB   $EC02       LDD 2,X
E23B DD       434:          FCB   $DD,N+4     STD N+4
E23C E4
E23D 08       435:          INX
E23E 08       436:          INX
E23F DF F0    437:          STX   XTEMP
E241 DC       438: CMOV2    FCB   $DC,N       LDD N
E242 E0
E243 83       439:          FCB   $83         SUB D #
E244 00 01    440:          FDB   1
E246 DD       441:          FCB   $DD,N       STD N
E247 E0
E248 25 10    442:          BCS   CMOV3
E24A DE E4    443:          LDX   N+4
E24C A6 00    444:          LDA A 0,X
E24E 08       445:          INX
E24F DF E4    446:          STX   N+4
E251 DE E2    447:          LDX   N+2
E253 A7 00    448:          STA A 0,X
E255 08       449:          INX
E256 DF E2    450:          STX   N+2
E258 20 E7    451:          BRA   CMOV2
E25A DE F0    452: CMOV3    LDX   XTEMP
E25C 39       453:          RTS
              454: *
E25D 82       455:          FCB   $82
E25E 55       456:          FCC   "U"
E25F AA       457:          FCB   $AA
E260 E2 25    458:          FDB   CMOVE-8
E262 09       459: USTAR    DEX
E263 09       460:          DEX
E264 09       461:          DEX
E265 09       462:          DEX
E266 A6 07    463:          LDA A 7,X
E268 E6 09    464:          LDA B 9,X
E26A 3D       465:          FCB   $3D         MUL
E26B ED 04    466:          FDB   $ED04       STD 4,X
E26D A6 06    467:          LDA A 6,X
E26F E6 08    468:          LDA B 8,X
E271 3D       469:          FCB   $3D         MUL
E272 ED 02    470:          FDB   $ED02       STD 2,X
E274 EC 07    471:          FDB   $EC07       LDD 7,X
E276 3D       472:          FCB   $3D         MUL
E277 ED 00    473:          FDB   $ED00       STD 0,X
E279 A6 06    474:          LDA A 6,X
E27B E6 09    475:          LDA B 9,X
E27D 3D       476:          FCB   $3D         MUL
E27E E3 00    477:          FDB   $E300       ADD D 0,X
E280 24 02    478:          BCC   USTAR2
E282 6C 02    479:          INC   2,X
E284 E3 03    480: USTAR2   FDB   $E303       ADD D 3,X
E286 24 02    481:          BCC   USTAR3
E288 6C 02    482:          INC   2,X
E28A ED 07    483: USTAR3   FDB   $ED07       STD 7,X
```

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```
E28C A6 05     484:          LDA A 5,X
E28E A7 09     485:          STA A 9,X
E290 A6 02     486:          LDA A 2,X
E292 A7 06     487:          STA A 6,X
E294 08        488:          INX
E295 08        489:          INX
E296 08        490:          INX
E297 08        491:          INX
E298 39        492:          RTS
               493: *
E299 82        494:          FCB   $82
E29A 55        495:          FCC   "U"
E29B AF        496:          FCB   $AF
E29C E2 5D     497:          FDB   USTAR-5
E29E 86 11     498: USLASH   LDA A #17
E2A0 08        499:          INX
E2A1 A7 00     500:          STA A 0,X
E2A3 EC 03     501:          FDB   $EC03       LDD 3,X
E2A5 A1 01     502: USL1     CMP A 1,X
E2A7 22 09     503:          BHI   USL3
E2A9 25 04     504:          BCS   USL2
E2AB E1 02     505:          CMP B 2,X
E2AD 24 03     506:          BCC   USL3
E2AF 0C        507: USL2     CLC
E2B0 20 03     508:          BRA   USL4
E2B2 A3 01     509: USL3     FDB   $A301       SUB D 1,X
E2B4 0D        510:          SEC
E2B5 69 06     511: USL4     ROL   6,X
E2B7 69 05     512:          ROL   5,X
E2B9 6A 00     513:          DEC   0,X
E2BB 27 06     514:          BEQ   USL5
E2BD 59        515:          ROL B
E2BE 49        516:          ROL A
E2BF 24 E4     517:          BCC   USL1
E2C1 20 EF     518:          BRA   USL3
E2C3 DD        519: USL5     FCB   $DD,XTEMP   STD XTEMP
E2C4 F0
E2C5 EC 05     520:          FDB   $EC05       LDD 5,X
E2C7 ED 03     521:          FDB   $ED03       STD 3,X
E2C9 DC        522:          FCB   $DC,XTEMP   LDD XTEMP
E2CA F0
E2CB ED 05     523:          FDB   $ED05       STD 5,X
E2CD 08        524:          INX
E2CE 39        525:          RTS
               526: *
E2CF 83        527:          FCB   $83
E2D0 41        528:          FCC   "AN"
E2D1 4E
E2D2 C4        529:          FCB   $C4
E2D3 E2 99     530:          FDB   USLASH-5
E2D5 08        531: AND      INY
E2D6 08        532:          INX
E2D7 EC 00     533:          FDB   $EC00       LDD 0,X
E2D9 E4 03     534:          AND B 3,X
E2DB A4 02     535:          AND A 2,X
E2DD ED 02     536:          FDB   $ED02       STD 2,X
E2DF 39        537:          RTS
               538: *
E2E0 82        539:          FCB   $82
E2E1 4F        540:          FCC   "O"
```

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```
E2E2 D2        541:          FCB   $D2
E2E3 E2 CF     542:          FDB   AND-6
E2E5 08        543: OR       INX
E2E6 08        544:          INX
E2E7 EC 00     545:          FDB   $EC00       LDD 0,X
E2E9 EA 03     546:          ORA B 3,X
E2EB AA 02     547:          ORA A 2,X
E2ED ED 02     548:          FDB   $ED02       STD 2,X
E2EF 39        549:          RTS
               550: *
E2F0 83        551:          FCB   $83
E2F1 58        552:          FCC   "XO"
E2F2 4F
E2F3 D2        553:          FCB   $D2
E2F4 E2 E0     554:          FDB   OR-5
E2F6 08        555: XOR      INX
E2F7 08        556:          INX
E2F8 EC 00     557:          FDB   $EC00       LDD 0,X
E2FA E8 03     558:          EOR B 3,X
E2FC A8 02     559:          EOR A 2,X
E2FE ED 02     560:          FDB   $ED02       STD 2,X
E300 39        561:          RTS
               562: *
E301 83        563:          FCB   $83
E302 53        564:          FCC   "SP"
E303 50
E304 C0        565:          FCB   $C0
E305 E2 F0     566:          FDB   XOR-6
E307 EF 00     567: SPAT     STX   0,X
E309 09        568:          DEX
E30A 09        569:          DEX
E30B 39        570:          RTS
               571: *
E30C 83        572:          FCB   $83
E30D 53        573:          FCC   "SP"
E30E 50
E30F A1        574:          FCB   $A1
E310 E3 01     575:          FDB   SPAT-6
E312 DE F2     576: SPSTOR   LDX   UP
E314 EE 06     577:          LDX   6,X
E316 39        578:          RTS
               579: *
E317 83        580:          FCB   $83
E318 52        581:          FCC   "RP"
E319 50
E31A A1        582:          FCB   $A1
E31B E3 0C     583:          FDB   SPSTOR-6
E31D 32        584: RPSTOR   PUL A
E31E 33        585:          PUL B
E31F BE E014   586:          LDS   RINIT
E322 37        587:          PSH B
E323 36        588:          PSH A
E324 39        589:          RTS
               590: *
E325 82        591:          FCB   $82
E326 3B        592:          FCC   ";"
E327 D3        593:          FCB   $D3
E328 E3 17     594:          FDB   RPSTOR-6
E32A BD E358   595: SEMIS    JSR   FROMR
E32D 39        596:          RTS
```

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FORTH                                          SSB MNEMONIC ASSEMBLER  PAGE 12

                    597: *
E32E 85             598:          FCB   $85
E32F 4C             599:          FCC   "LEAV"
E330 45 41
E332 56
E333 C5             600:          FCB   $C5
E334 E3 25          601:          FDB   SEMIS-5
E336 DF F0          602: LEAVE    STX   XTEMP
E338 30             603:          TSX
E339 EC 02          604:          FDB   $EC02       LDD 2,X
E33B ED 04          605:          FDB   $ED04       STD 4,X
E33D DE F0          606:          LDX   XTEMP
E33F 39             607:          RTS
                    608: *
E340 82             609:          FCB   $82
E341 3E             610:          FCC   ">"
E342 D2             611:          FCB   $D2
E343 E3 2E          612:          FDB   LEAVE-8
E345 08             613: TOR      INX
E346 08             614:          INX
E347 DF F0          615:          STX   XTEMP
E349 EE 00          616:          LDX   0,X
E34B 32             617:          PUL A
E34C 33             618:          PUL B
E34D 3C             619:          FCB   $3C         PSHX
E34E 37             620:          PSH B
E34F 36             621:          PSH A
E350 DE F0          622:          LDX   XTEMP
E352 39             623:          RTS
                    624: *
E353 82             625:          FCB   $82
E354 52             626:          FCC   "R"
E355 BE             627:          FCB   $BE
E356 E3 40          628:          FDB   TOR-5
E358 DF F0          629: FROMR    STX   XTEMP
E35A 38             630:          FCB   $38         PULX
E35B 18             631:          FCB   $18         XGDX
E35C 38             632:          FCB   $38         PULX
E35D 18             633:          FCB   $18         XGDX
E35E 3C             634:          FCB   $3C         PSHX
E35F DE F0          635:          LDX   XTEMP
E361 ED 00          636:          FDB   $ED00       STD 0,X
E363 09             637:          DEX
E364 09             638:          DEX
E365 39             639:          RTS
                    640: *
E366 81             641:          FCB   $81
E367 D2             642:          FCB   $D2
E368 E3 53          643:          FDB   FROMR-5
E36A DF F0          644: R        STX   XTEMP
E36C 30             645:          TSX
E36D EC 02          646:          FDB   $EC02       LDD 2,X
E36F DE F0          647:          LDX   XTEMP
E371 ED 00          648:          FDB   $ED00       STD 0,X
E373 09             649:          DEX
E374 09             650:          DEX
E375 39             651:          RTS
                    652: *
E376 82             653:          FCB   $82
E377 30             654:          FCC   "0"
```

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```
E378 BD        655:          FCB   $BD
E379 E3 66     656:          FDB   R-4
E37B EC 02     657: ZEQU     FDB   $EC02        LDD 2,X
E37D 27 03     658:          BEQ   ZEQU2
E37F 4F        659:          CLR A
E380 C6 FF     660:          LDA B #$FF
E382 5C        661: ZEQU2    INC B
E383 ED 02     662:          FDB   $ED02        STD 2,X
E385 39        663:          RTS
               664: *
E386 82        665:          FCB   $82
E387 30        666:          FCC   "0"
E388 BC        667:          FCB   $BC
E389 E3 76     668:          FDB   ZEQU-5
E38B 5F        669: ZLESS    CLR B
E38C A6 02     670:          LDA A 2,X
E38E 2A 01     671:          BPL   ZLESS2
E390 5C        672:          INC B
E391 4F        673: ZLESS2   CLR A
E392 ED 02     674:          FDB   $ED02        STD 2,X
E394 39        675:          RTS
               676: *
E395 81        677:          FCB   $81
E396 AB        678:          FCB   $AB
E397 E3 86     679:          FDB   ZLESS-5
E399 EC 02     680: PLUS     FDB   $EC02        LDD 2,X
E39B E3 04     681:          FDB   $E304        ADD D 4,X
E39D ED 04     682:          FDB   $ED04        STD 4,X
E39F 08        683:          INX
E3A0 08        684:          INX
E3A1 39        685:          RTS
               686: *
E3A2 82        687:          FCB   $82
E3A3 44        688:          FCC   "D"
E3A4 AB        689:          FCB   $AB
E3A5 E3 95     690:          FDB   PLUS-4
E3A7 EC 04     691: DPLUS    FDB   $EC04        LDD 4,X
E3A9 E3 08     692:          FDB   $E308        ADD D 8,X
E3AB ED 08     693:          FDB   $ED08        STD 8,X
E3AD EC 02     694:          FDB   $EC02        LDD 2,X
E3AF E9 07     695:          ADC B 7,X
E3B1 A9 06     696:          ADC A 6,X
E3B3 ED 06     697:          FDB   $ED06        STD 6,X
E3B5 08        698:          INX
E3B6 08        699:          INX
E3B7 08        700:          INX
E3B8 08        701:          INX
E3B9 39        702:          RTS
               703: *
E3BA 85        704:          FCB   $85
E3BB 4D        705:          FCC   "MINU"
E3BC 49 4E
E3BE 55
E3BF D3        706:          FCB   $D3
E3C0 E3 A2     707:          FDB   DPLUS-5
E3C2 4F        708: MINUS    CLR A
E3C3 5F        709:          CLR B
E3C4 A3 02     710:          FDB   $A302        SUB D 2,X
E3C6 ED 02     711:          FDB   $ED02        STD 2,X
E3C8 39        712:          RTS
```

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```
                713: *
E3C9 86         714:          FCB   $86
E3CA 44         715:          FCC   "DMINU"
E3CB 4D 49
E3CD 4E 55
E3CF D3         716:          FCB   $D3
E3D0 E3 BA      717:          FDB   MINUS-8
E3D2 4F         718: DMINUS   CLR A
E3D3 5F         719:          CLR B
E3D4 A3 04      720:          FDB   $A304       SUB D 4,X
E3D6 ED 04      721:          FDB   $ED04       STD 4,X
E3D8 CC         722:          FCB   $CC         LDD #
E3D9 00 00      723:          FDB   0
E3DB E2 03      724:          SBC B 3,X
E3DD A2 02      725:          SBC A 2,X
E3DF ED 02      726:          FDB   $ED02       STD 2,X
E3E1 39         727:          RTS
                728: *
E3E2 84         729:          FCB   $84
E3E3 4F         730:          FCC   "OVE"
E3E4 56 45
E3E6 D2         731:          FCB   $D2
E3E7 E3 C9      732:          FDB   DMINUS-9
E3E9 EC 04      733: OVER     FDB   $EC04       LDD 4,X
E3EB ED 00      734:          FDB   $ED00       STD 0,X
E3ED 09         735:          DEX
E3EE 09         736:          DEX
E3EF 39         737:          RTS
                738: *
E3F0 84         739:          FCB   $84
E3F1 44         740:          FCC   "DRO"
E3F2 52 4F
E3F4 D0         741:          FCB   $D0
E3F5 E3 E2      742:          FDB   OVER-7
E3F7 08         743: DROP     INX
E3F8 08         744:          INX
E3F9 39         745:          RTS
                746: *
E3FA 84         747:          FCB   $84
E3FB 53         748:          FCC   "SWA"
E3FC 57 41
E3FE D0         749:          FCB   $D0
E3FF E3 F0      750:          FDB   DROP-7
E401 EC 02      751: SWAP     FDB   $EC02       LDD 2,X
E403 DD         752:          FCB   $DD,XTEMP   STD XTEMP
E404 F0
E405 EC 04      753:          FDB   $EC04       LDD 4,X
E407 ED 02      754:          FDB   $ED02       STD 2,X
E409 DC         755:          FCB   $DC,XTEMP   LDD XTEMP
E40A F0
E40B ED 04      756:          FDB   $ED04       STD 4,X
E40D 39         757:          RTS
                758: *
E40E 83         759:          FCB   $83
E40F 44         760:          FCC   "DU"
E410 55
E411 D0         761:          FCB   $D0
E412 E3 FA      762:          FDB   SWAP-7
E414 EC 02      763: DUP      FDB   $EC02       LDD 2,X
E416 ED 00      764:          FDB   $ED00       STD 0,X
```

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```
E418 09       765:          DEX
E419 09       766:          DEX
E41A 39       767:          RTS
              768: *
E41B 82       769:          FCB   $82
E41C 2B       770:          FCC   "+"
E41D A1       771:          FCB   $A1
E41E E4 0E    772:          FDB   DUP-6
E420 EC 04    773: PSTORE   FDB   $EC04       LDD 4,X
E422 DF F0    774:          STX   XTEMP
E424 EE 02    775:          LDX   2,X
E426 E3 00    776:          FDB   $E300       ADD D 0,X
E428 ED 00    777:          FDB   $ED00       STD 0,X
E42A DE F0    778:          LDX   XTEMP
E42C 08       779:          INX
E42D 08       780:          INX
E42E 08       781:          INX
E42F 08       782:          INX
E430 39       783:          RTS
              784: *
E431 86       785:          FCB   $86
E432 54       786:          FCC   "TOGGL"
E433 4F 47
E435 47 4C
E437 C5       787:          FCB   $C5
E438 E4 1B    788:          FDB   PSTORE-5
E43A BD E3E9  789: TOGGLE   JSR   OVER
E43D BD E45E  790:          JSR   CAT
E440 BD E2F6  791:          JSR   XOR
E443 BD E401  792:          JSR   SWAP
E446 BD E482  793:          JSR   CSTORE
E449 39       794:          RTS
              795: *
E44A 81       796:          FCB   $81
E44B C0       797:          FCB   $C0
E44C E4 31    798:          FDB   TOGGLE-9
E44E DF F0    799: AT       STX   XTEMP
E450 EE 02    800:          LDX   2,X
E452 EC 00    801:          FDB   $EC00       LDD 0,X
E454 DE F0    802:          LDX   XTEMP
E456 ED 02    803:          FDB   $ED02       STD 2,X
E458 39       804:          RTS
              805: *
E459 82       806:          FCB   $82
E45A 43       807:          FCC   "C"
E45B C0       808:          FCB   $C0
E45C E4 4A    809:          FDB   AT-4
E45E DF F0    810: CAT      STX   XTEMP
E460 EE 02    811:          LDX   2,X
E462 4F       812:          CLR A
E463 E6 00    813:          LDA B 0,X
E465 DE F0    814:          LDX   XTEMP
E467 ED 02    815:          FDB   $ED02       STD 2,X
E469 39       816:          RTS
              817: *
E46A 81       818:          FCB   $81
E46B A1       819:          FCB   $A1
E46C E4 59    820:          FDB   CAT-5
E46E EC 04    821: STORE    FDB   $EC04       LDD 4,X
E470 DF F0    822:          STX   XTEMP
```

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```
E472 EE 02     823:          LDX   2,X
E474 ED 00     824:          FDB   $ED00       STD 0,X
E476 DE F0     825:          LDX   XTEMP
E478 08        826:          INX
E479 08        827:          INX
E47A 08        828:          INX
E47B 08        829:          INX
E47C 39        830:          RTS
               831: *
E47D 82        832:          FCB   $82
E47E 43        833:          FCC   "C"
E47F A1        834:          FCB   $A1
E480 E4 6A     835:          FDB   STORE-4
E482 E6 05     836: CSTORE   LDA B 5,X
E484 DF F0     837:          STX   XTEMP
E486 EE 02     838:          LDX   2,X
E488 E7 00     839:          STA B 0,X
E48A DE F0     840:          LDX   XTEMP
E48C 08        841:          INX
E48D 08        842:          INX
E48E 08        843:          INX
E48F 08        844:          INX
E490 39        845:          RTS
               846: *
E491 C1        847:          FCB   $C1
E492 BA        848:          FCB   $BA
E493 E4 7D     849:          FDB   CSTORE-5
E495 BD E86C   850: COLON    JSR   QEXEC
E498 BD E827   851:          JSR   SCSP
E49B BD E648   852:          JSR   CURENT
E49E BD E44E   853:          JSR   AT
E4A1 BD E639   854:          JSR   CONTXT
E4A4 BD E46E   855:          JSR   STORE
E4A7 BD EE59   856:          JSR   CREATE
E4AA BD E903   857:          JSR   RBRAK
E4AD 39        858:          RTS
               859: *
E4AE C1        860:          FCB   $C1
E4AF BB        861:          FCB   $BB
E4B0 E4 91     862:          FDB   COLON-4
E4B2 BD E895   863: SEMI     JSR   QCSP
E4B5 BD E044   864:          JSR   CLITER
E4B8 39        865:          FCB   $39
E4B9 BD E6F6   866:          JSR   CCOMM
E4BC BD E917   867:          JSR   SMUDGE
E4BF BD E8F5   868:          JSR   LBRAK
E4C2 39        869:          RTS
               870: *
E4C3 88        871:          FCB   $88
E4C4 43        872:          FCC   "CONSTAN"
E4C5 4F 4E
E4C7 53 54
E4C9 41 4E
E4CB D4        873:          FCB   $D4
E4CC E4 AE     874:          FDB   SEMI-4
E4CE BD EE59   875: CON      JSR   CREATE
E4D1 BD E917   876:          JSR   SMUDGE
E4D4 BD E53E   877:          JSR   THREE
E4D7 BD E6D9   878:          JSR   ALLOT
E4DA BD E6E4   879:          JSR   COMMA
```

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```
E4DD BD E952   880:          JSR   PSCODE
E4E0 DF F0     881: DOCON    STX   XTEMP
E4E2 38        882:          FCB   $38          PULX
E4E3 EC 00     883:          FDB   $EC00         LDD 0,X
E4E5 DE F0     884:          LDX   XTEMP
E4E7 ED 00     885:          FDB   $ED00         STD 0,X
E4E9 09        886:          DEX
E4EA 09        887:          DEX
E4EB 39        888:          RTS
               889: *
E4EC 88        890:          FCB   $88
E4ED 56        891:          FCC   "VARIABL"
E4EE 41 52
E4F0 49 41
E4F2 42 4C
E4F4 C5        892:          FCB   $C5
E4F5 E4 C3     893:          FDB   CON-11
E4F7 BD E4CE   894: VAR      JSR   CON
E4FA BD E952   895:          JSR   PSCODE
E4FD 32        896: DOVAR    PUL A
E4FE 33        897:          PUL B
E4FF ED 00     898:          FDB   $ED00         STD 0,X
E501 09        899:          DEX
E502 09        900:          DEX
E503 39        901:          RTS
               902: *
E504 84        903:          FCB   $84
E505 55        904:          FCC   "USE"
E506 53 45
E508 D2        905:          FCB   $D2
E509 E4 EC     906:          FDB   VAR-11
E50B BD E4CE   907: USER     JSR   CON
E50E BD E952   908:          JSR   PSCODE
E511 DF F0     909: DOUSER   STX   XTEMP
E513 38        910:          FCB   $38          PULX
E514 EC 00     911:          FDB   $EC00         LDD 0,X
E516 DE F0     912:          LDX   XTEMP
E518 D3        913:          FCB   $D3,UP        ADD D UP
E519 F2
E51A ED 00     914:          FDB   $ED00         STD 0,X
E51C 09        915:          DEX
E51D 09        916:          DEX
E51E 39        917:          RTS
               918: *
E51F 81        919:          FCB   $81
E520 B0        920:          FCB   $B0
E521 E5 04     921:          FDB   USER-7
E523 BD E4E0   922: ZERO     JSR   DOCON
E526 00 00     923:          FDB   0
               924: *
E528 81        925:          FCB   $81
E529 B1        926:          FCB   $B1
E52A E5 1F     927:          FDB   ZERO-4
E52C BD E4E0   928: ONE      JSR   DOCON
E52F 00 01     929:          FDB   1
               930: *
E531 81        931:          FCB   $81
E532 B2        932:          FCB   $B2
E533 E5 28     933:          FDB   ONE-4
E535 BD E4E0   934: TWO      JSR   DOCON
```

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```
E538 00 02      935:          FDB   2
                936: *
E53A 81         937:          FCB   $81
E53B B3         938:          FCB   $B3
E53C E5 31      939:          FDB   TWO-4
E53E BD E4E0    940: THREE    JSR   DOCON
E541 00 03      941:          FDB   3
                942: *
E543 82         943:          FCB   $82
E544 42         944:          FCC   "B"
E545 CC         945:          FCB   $CC
E546 E5 3A      946:          FDB   THREE-4
E548 BD E4E0    947: BL       JSR   DOCON
E54B 00 20      948:          FDB   $20
                949: *
E54D 85         950:          FCB   $85
E54E 46         951:          FCC   "FIRS"
E54F 49 52
E551 53
E552 D4         952:          FCB   $D4
E553 E5 43      953:          FDB   BL-5
E555 BD E4E0    954: FIRST    JSR   DOCON
E558 DD E0      955:          FDB   MEMEND/NBLK-68*NBLK
                956: *
E55A 85         957:          FCB   $85
E55B 4C         958:          FCC   "LIMI"
E55C 49 4D
E55E 49
E55F D4         959:          FCB   $D4
E560 E5 4D      960:          FDB   FIRST-8
E562 BD E4E0    961: LIMIT    JSR   DOCON
E565 E0 00      962:          FDB   MEMEND
                963: *
E567 85         964:          FCB   $85
E568 42         965:          FCC   "B/BU"
E569 2F 42
E56B 55
E56C C6         966:          FCB   $C6
E56D E5 5A      967:          FDB   LIMIT-8
E56F BD E4E0    968: BBUF     JSR   DOCON
E572 00 40      969:          FDB   64
                970: *
E574 85         971:          FCB   $85
E575 42         972:          FCC   "B/SC"
E576 2F 53
E578 43
E579 D2         973:          FCB   $D2
E57A E5 67      974:          FDB   BBUF-8
E57C BD E4E0    975: BSCR     JSR   DOCON
E57F 00 10      976:          FDB   16
                977: *
E581 87         978:          FCB   $87
E582 2B         979:          FCC   "+ORIGI"
E583 4F 52
E585 49 47
E587 49
E588 CE         980:          FCB   $CE
E589 E5 74      981:          FDB   BSCR-8
E58B BD E02C    982: PORIG    JSR   LIT
E58E E0 00      983:          FDB   ORIG
```

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```
E590 BD E399   984:          JSR   PLUS
E593 39        985:          RTS
               986: *
E594 82        987:          FCB   $82
E595 53        988:          FCC   "S"
E596 B0        989:          FCB   $B0
E597 E5 81     990:          FDB   PORIG-10
E599 BD E511   991: SZERO     JSR   DOUSER
E59C 00 06     992:          FDB   XSPZER-UORIG
               993: *
E59E 82        994:          FCB   $82
E59F 52        995:          FCC   "R"
E5A0 B0        996:          FCB   $B0
E5A1 E5 94     997:          FDB   SZERO-5
E5A3 BD E511   998: RZERO     JSR   DOUSER
E5A6 00 08     999:          FDB   XRZERO-UORIG
              1000: *
E5A8 83       1001:          FCB   $83
E5A9 54       1002:          FCC   "TI"
E5AA 49
E5AB C2       1003:          FCB   $C2
E5AC E5 9E    1004:          FDB   RZERO-5
E5AE BD E511  1005: TIB      JSR   DOUSER
E5B1 00 0A    1006:          FDB   XTIB-UORIG
              1007: *
E5B3 85       1008:          FCB   $85
E5B4 57       1009:          FCC   "WIDT"
E5B5 49 44
E5B7 54
E5B8 C8       1010:          FCB   $C8
E5B9 E5 A8    1011:          FDB   TIB-6
E5BB BD E511  1012: WIDTH    JSR   DOUSER
E5BE 00 0C    1013:          FDB   XWIDTH-UORIG
              1014: *
E5C0 87       1015:          FCB   $87
E5C1 57       1016:          FCC   "WARNIN"
E5C2 41 52
E5C4 4E 49
E5C6 4E
E5C7 C7       1017:          FCB   $C7
E5C8 E5 B3    1018:          FDB   WIDTH-8
E5CA BD E511  1019: WARN     JSR   DOUSER
E5CD 00 0E    1020:          FDB   XWARN-UORIG
              1021: *
E5CF 85       1022:          FCB   $85
E5D0 46       1023:          FCC   "FENC"
E5D1 45 4E
E5D3 43
E5D4 C5       1024:          FCB   $C5
E5D5 E5 C0    1025:          FDB   WARN-10
E5D7 BD E511  1026: FENCE    JSR   DOUSER
E5DA 00 10    1027:          FDB   XFENCE-UORIG
              1028: *
E5DC 82       1029:          FCB   $82
E5DD 44       1030:          FCC   "D"
E5DE D0       1031:          FCB   $D0
E5DF E5 CF    1032:          FDB   FENCE-8
E5E1 BD E511  1033: DP       JSR   DOUSER
E5E4 00 12    1034:          FDB   XDP-UORIG
              1035: *
```

```
E5E6 88       1036:          FCB   $88
E5E7 56       1037:          FCC   "VOC-LIN"
E5E8 4F 43
E5EA 2D 4C
E5EC 49 4E
E5EE CB       1038:          FCB   $CB
E5EF E5 DC    1039:          FDB   DP-5
E5F1 BD E511  1040: VOCLIN   JSR   DOUSER
E5F4 00 14    1041:          FDB   XVOCL-UORIG
              1042: *
E5F6 83       1043:          FCB   $83
E5F7 42       1044:          FCC   "BL"
E5F8 4C
E5F9 CB       1045:          FCB   $CB
E5FA E5 E6    1046:          FDB   VOCLIN-11
E5FC BD E511  1047: BLK      JSR   DOUSER
E5FF 00 16    1048:          FDB   XBLK-UORIG
              1049: *
E601 82       1050:          FCB   $82
E602 49       1051:          FCC   "I"
E603 CE       1052:          FCB   $CE
E604 E5 F6    1053:          FDB   BLK-6
E606 BD E511  1054: IN       JSR   DOUSER
E609 00 18    1055:          FDB   XIN-UORIG
              1056: *
E60B 83       1057:          FCB   $83
E60C 4F       1058:          FCC   "OU"
E60D 55
E60E D4       1059:          FCB   $D4
E60F E6 01    1060:          FDB   IN-5
E611 BD E511  1061: OUT      JSR   DOUSER
E614 00 1A    1062:          FDB   XOUT-UORIG
              1063: *
E616 83       1064:          FCB   $83
E617 53       1065:          FCC   "SC"
E618 43
E619 D2       1066:          FCB   $D2
E61A E6 0B    1067:          FDB   OUT-6
E61C BD E511  1068: SCR      JSR   DOUSER
E61F 00 1C    1069:          FDB   XSCR-UORIG
              1070: *
E621 86       1071:          FCB   $86
E622 4F       1072:          FCC   "OFFSE"
E623 46 46
E625 53 45
E627 D4       1073:          FCB   $D4
E628 E6 16    1074:          FDB   SCR-6
E62A BD E511  1075: OFSET    JSR   DOUSER
E62D 00 1E    1076:          FDB   XOFSET-UORIG
              1077: *
E62F 87       1078:          FCB   $87
E630 43       1079:          FCC   "CONTEX"
E631 4F 4E
E633 54 45
E635 58
E636 D4       1080:          FCB   $D4
E637 E6 21    1081:          FDB   OFSET-9
E639 BD E511  1082: CONTXT   JSR   DOUSER
E63C 00 20    1083:          FDB   XCONT-UORIG
              1084: *
```

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```
E63E 87       1085:          FCB   $87
E63F 43       1086:          FCC   "CURREN"
E640 55 52
E642 52 45
E644 4E
E645 D4       1087:          FCB   $D4
E646 E6 2F    1088:          FDB   CONTXT-10
E648 BD E511  1089: CURENT   JSR   DOUSER
E64B 00 22    1090:          FDB   XCURR-UORIG
              1091: *
E64D 85       1092:          FCB   $85
E64E 53       1093:          FCC   "STAT"
E64F 54 41
E651 54
E652 C5       1094:          FCB   $C5
E653 E6 3E    1095:          FDB   CURENT-10
E655 BD E511  1096: STATE    JSR   DOUSER
E658 00 24    1097:          FDB   XSTATE-UORIG
              1098: *
E65A 84       1099:          FCB   $84
E65B 42       1100:          FCC   "BAS"
E65C 41 53
E65E C5       1101:          FCB   $C5
E65F E6 4D    1102:          FDB   STATE-8
E661 BD E511  1103: BASE     JSR   DOUSER
E664 00 26    1104:          FDB   XBASE-UORIG
              1105: *
E666 83       1106:          FCB   $83
E667 44       1107:          FCC   "DP"
E668 50
E669 CC       1108:          FCB   $CC
E66A E6 5A    1109:          FDB   BASE-7
E66C BD E511  1110: DPL      JSR   DOUSER
E66F 00 28    1111:          FDB   XDPL-UORIG
              1112: *
E671 83       1113:          FCB   $83
E672 46       1114:          FCC   "FL"
E673 4C
E674 C4       1115:          FCB   $C4
E675 E6 66    1116:          FDB   DPL-6
E677 BD E511  1117: FLD      JSR   DOUSER
E67A 00 2A    1118:          FDB   XFLD-UORIG
              1119: *
E67C 83       1120:          FCB   $83
E67D 43       1121:          FCC   "CS"
E67E 53
E67F D0       1122:          FCB   $D0
E680 E6 71    1123:          FDB   FLD-6
E682 BD E511  1124: CSP      JSR   DOUSER
E685 00 2C    1125:          FDB   XCSP-UORIG
              1126: *
E687 82       1127:          FCB   $82
E688 52       1128:          FCC   "R"
E689 A3       1129:          FCB   $A3
E68A E6 7C    1130:          FDB   CSP-6
E68C BD E511  1131: RNUM     JSR   DOUSER
E68F 00 2E    1132:          FDB   XRNUM-UORIG
              1133: *
E691 83       1134:          FCB   $83
E692 48       1135:          FCC   "HL"
```

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```
E693 4C
E694 C4          1136:           FCB   $C4
E695 E6 87       1137:           FDB   RNUM-5
E697 BD E4E0     1138: HLD       JSR   DOCON
E69A 40 30       1139:           FDB   XHLD
                 1140: *
E69C 87          1141:           FCB   $87
E69D 43          1142:           FCC   "COLUMN"
E69E 4F 4C
E6A0 55 4D
E6A2 4E
E6A3 D3          1143:           FCB   $D3
E6A4 E6 91       1144:           FDB   HLD-6
E6A6 BD E511     1145: COLUMS    JSR   DOUSER
E6A9 00 34       1146:           FDB   XCOLUMS-UORIG
                 1147: *
E6AB 82          1148:           FCB   $82
E6AC 31          1149:           FCC   "1"
E6AD AB          1150:           FCB   $AB
E6AE E6 9C       1151:           FDB   COLUMS-10
E6B0 BD E52C     1152: ONEP      JSR   ONE
E6B3 BD E399     1153:           JSR   PLUS
E6B6 39          1154:           RTS
                 1155: *
E6B7 82          1156:           FCB   $82
E6B8 32          1157:           FCC   "2"
E6B9 AB          1158:           FCB   $AB
E6BA E6 AB       1159:           FDB   ONEP-5
E6BC BD E535     1160: TWOP      JSR   TWO
E6BF BD E399     1161:           JSR   PLUS
E6C2 39          1162:           RTS
                 1163: *
E6C3 84          1164:           FCB   $84
E6C4 48          1165:           FCC   "HER"
E6C5 45 52
E6C7 C5          1166:           FCB   $C5
E6C8 E6 B7       1167:           FDB   TWOP-5
E6CA BD E5E1     1168: HERE      JSR   DP
E6CD BD E44E     1169:           JSR   AT
E6D0 39          1170:           RTS
                 1171: *
E6D1 85          1172:           FCB   $85
E6D2 41          1173:           FCC   "ALLO"
E6D3 4C 4C
E6D5 4F
E6D6 D4          1174:           FCB   $D4
E6D7 E6 C3       1175:           FDB   HERE-7
E6D9 BD E5E1     1176: ALLOT     JSR   DP
E6DC BD E420     1177:           JSR   PSTORE
E6DF 39          1178:           RTS
                 1179: *
E6E0 81          1180:           FCB   $81
E6E1 AC          1181:           FCB   $AC
E6E2 E6 D1       1182:           FDB   ALLOT-8
E6E4 BD E6CA     1183: COMMA     JSR   HERE
E6E7 BD E46E     1184:           JSR   STORE
E6EA BD E535     1185:           JSR   TWO
E6ED BD E6D9     1186:           JSR   ALLOT
E6F0 39          1187:           RTS
                 1188: *
```

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```
E6F1 82       1189:          FCB   $82
E6F2 43       1190:          FCC   "C"
E6F3 AC       1191:          FCB   $AC
E6F4 E6 E0    1192:          FDB   COMMA-4
E6F6 BD E6CA  1193: CCOMM    JSR   HERE
E6F9 BD E482  1194:          JSR   CSTORE
E6FC BD E52C  1195:          JSR   ONE
E6FF BD E6D9  1196:          JSR   ALLOT
E702 39       1197:          RTS
              1198: *
E703 81       1199:          FCB   $81
E704 AD       1200:          FCB   $AD
E705 E6 F1    1201:          FDB   CCOMM-5
E707 BD E3C2  1202: SUB      JSR   MINUS
E70A BD E399  1203:          JSR   PLUS
E70D 39       1204:          RTS
              1205: *
E70E 81       1206:          FCB   $81
E70F BD       1207:          FCB   $BD
E710 E7 03    1208:          FDB   SUB-4
E712 BD E707  1209: EQUAL    JSR   SUB
E715 BD E37B  1210:          JSR   ZEQU
E718 39       1211:          RTS
              1212: *
E719 81       1213:          FCB   $81
E71A BC       1214:          FCB   $BC
E71B E7 0E    1215:          FDB   EQUAL-4
E71D EC 02    1216: LESS     FDB   $EC02       LDD 2,X
E71F A1 04    1217:          CMP A 4,X
E721 2E 09    1218:          BGT   LESST
E723 26 04    1219:          BNE   LESSF
E725 E1 05    1220:          CMP B 5,X
E727 22 03    1221:          BHI   LESST
E729 5F       1222: LESSF    CLR B
E72A 20 02    1223:          BRA   LESSX
E72C C6 01    1224: LESST    LDA B #1
E72E 4F       1225: LESSX    CLR A
E72F ED 04    1226:          FDB   $ED04       STD 4,X
E731 08       1227:          INX
E732 08       1228:          INX
E733 39       1229:          RTS
              1230: *
E734 81       1231:          FCB   $81
E735 BE       1232:          FCB   $BE
E736 E7 19    1233:          FDB   LESS-4
E738 BD E401  1234: GREAT    JSR   SWAP
E73B BD E71D  1235:          JSR   LESS
E73E 39       1236:          RTS
              1237: *
E73F 83       1238:          FCB   $83
E740 52       1239:          FCC   "RO"
E741 4F
E742 D4       1240:          FCB   $D4
E743 E7 34    1241:          FDB   GREAT-4
E745 BD E345  1242: ROT      JSR   TOR
E748 BD E401  1243:          JSR   SWAP
E74B BD E358  1244:          JSR   FROMR
E74E BD E401  1245:          JSR   SWAP
E751 39       1246:          RTS
              1247: *
```

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```
E752 85       1248:          FCB   $85
E753 53       1249:          FCC   "SPAC"
E754 50 41
E756 43
E757 C5       1250:          FCB   $C5
E758 E7 3F    1251:          FDB   ROT-6
E75A BD E548  1252: SPACE    JSR   BL
E75D BD E1DC  1253:          JSR   EMIT
E760 39       1254:          RTS
              1255: *
E761 83       1256:          FCB   $83
E762 4D       1257:          FCC   "MI"
E763 49
E764 CE       1258:          FCB   $CE
E765 E7 52    1259:          FDB   SPACE-8
E767 BD E3E9  1260: MIN      JSR   OVER
E76A BD E3E9  1261:          JSR   OVER
E76D BD E738  1262:          JSR   GREAT
E770 BD E06E  1263:          JSR   ZBRAN
E773 27 03    1264:          BEQ   MIN2
E775 BD E401  1265:          JSR   SWAP
E778 BD E3F7  1266: MIN2     JSR   DROP
E77B 39       1267:          RTS
              1268: *
E77C 83       1269:          FCB   $83
E77D 4D       1270:          FCC   "MA"
E77E 41
E77F D8       1271:          FCB   $D8
E780 E7 61    1272:          FDB   MIN-6
E782 BD E3E9  1273: MAX      JSR   OVER
E785 BD E3E9  1274:          JSR   OVER
E788 BD E71D  1275:          JSR   LESS
E78B BD E06E  1276:          JSR   ZBRAN
E78E 27 03    1277:          BEQ   MAX2
E790 BD E401  1278:          JSR   SWAP
E793 BD E3F7  1279: MAX2     JSR   DROP
E796 39       1280:          RTS
              1281: *
E797 84       1282:          FCB   $84
E798 2D       1283:          FCC   "-DU"
E799 44 55
E79B D0       1284:          FCB   $D0
E79C E7 7C    1285:          FDB   MAX-6
E79E BD E414  1286: DDUP     JSR   DUP
E7A1 BD E06E  1287:          JSR   ZBRAN
E7A4 27 03    1288:          BEQ   DDUP2
E7A6 BD E414  1289:          JSR   DUP
E7A9 39       1290: DDUP2    RTS
              1291: *
E7AA 88       1292:          FCB   $88
E7AB 54       1293:          FCC   "TRAVERS"
E7AC 52 41
E7AE 56 45
E7B0 52 53
E7B2 C5       1294:          FCB   $C5
E7B3 E7 97    1295:          FDB   DDUP-7
E7B5 BD E401  1296: TRAV     JSR   SWAP
E7B8 BD E3E9  1297: TRAV2    JSR   OVER
E7BB BD E399  1298:          JSR   PLUS
E7BE BD E044  1299:          JSR   CLITER
```

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```
E7C1 7F       1300:          FCB   $7F
E7C2 BD E3E9  1301:          JSR   OVER
E7C5 BD E45E  1302:          JSR   CAT
E7C8 BD E71D  1303:          JSR   LESS
E7CB BD E06E  1304:          JSR   ?BRAN
E7CE 27 E8    1305:          BEQ   TRAV2
E7D0 BD E401  1306:          JSR   SWAP
E7D3 BD E3F7  1307:          JSR   DROP
E7D6 39       1308:          RTS
              1309: *
E7D7 86       1310:          FCB   $86
E7D8 4C       1311:          FCC   "LATES"
E7D9 41 54
E7DB 45 53
E7DD D4       1312:          FCB   $D4
E7DE E7 AA    1313:          FDB   TRAV-11
E7E0 BD E648  1314: LATEST   JSR   CURENT
E7E3 BD E44E  1315:          JSR   AT
E7E6 BD E44E  1316:          JSR   AT
E7E9 39       1317:          RTS
              1318: *
E7EA 83       1319:          FCB   $83
E7EB 4C       1320:          FCC   "LF"
E7EC 46
E7ED C1       1321:          FCB   $C1
E7EE E7 D7    1322:          FDB   LATEST-9
E7F0 BD E535  1323: LFA      JSR   TWO
E7F3 BD E707  1324:          JSR   SUB
E7F6 39       1325:          RTS
              1326: *
E7F7 83       1327:          FCB   $83
E7F8 4E       1328:          FCC   "NF"
E7F9 46
E7FA C1       1329:          FCB   $C1
E7FB E7 EA    1330:          FDB   LFA-6
E7FD BD E53E  1331: NFA      JSR   THREE
E800 BD E707  1332:          JSR   SUB
E803 BD E52C  1333:          JSR   ONE
E806 BD E3C2  1334:          JSR   MINUS
E809 BD E7B5  1335:          JSR   TRAV
E80C 39       1336:          RTS
              1337: *
E80D 83       1338:          FCB   $83
E80E 50       1339:          FCC   "PF"
E80F 46
E810 C1       1340:          FCB   $C1
E811 E7 F7    1341:          FDB   NFA-6
E813 BD E52C  1342: PFA      JSR   ONE
E816 BD E7B5  1343:          JSR   TRAV
E819 BD E53E  1344:          JSR   THREE
E81C BD E399  1345:          JSR   PLUS
E81F 39       1346:          RTS
              1347: *
E820 84       1348:          FCB   $84
E821 21       1349:          FCC   "!CS"
E822 43 53
E824 D0       1350:          FCB   $D0
E825 E8 0D    1351:          FDB   PFA-6
E827 BD E307  1352: SCSP     JSR   SPAT
E82A BD E682  1353:          JSR   CSP
```

FORTH SSB MNEMONIC ASSEMBLER PAGE 26

```
E82D BD E46E 1354:          JSR   STORE
E830 39      1355:          RTS
             1356: *
E831 86      1357:          FCB   $86
E832 3F      1358:          FCC   "?ERRO"
E833 45 52
E835 52 4F
E837 D2      1359:          FCB   $D2
E838 E8 20   1360:          FDB   SCSP-7
E83A BD E401 1361: QERR     JSR   SWAP
E83D BD E06E 1362:          JSR   ZBRAN
E840 27 05   1363:          BEQ   QERR2
E842 BD EDD8 1364:          JSR   ERROR
E845 20 03   1365:          BRA   QERR3
E847 BD E3F7 1366: QERR2    JSR   DROP
E84A 39      1367: QERR3    RTS
             1368: *
E84B 85      1369:          FCB   $85
E84C 3F      1370:          FCC   "?COM"
E84D 43 4F
E84F 4D
E850 D0      1371:          FCB   $D0
E851 E8 31   1372:          FDB   QERR-9
E853 BD E655 1373: QCOMP    JSR   STATE
E856 BD E44E 1374:          JSR   AT
E859 BD E37B 1375:          JSR   ZEQU
E85C BD E044 1376:          JSR   CLITER
E85F 11      1377:          FCB   $11
E860 BD E83A 1378:          JSR   QERR
E863 39      1379:          RTS
             1380: *
E864 85      1381:          FCB   $85
E865 3F      1382:          FCC   "?EXE"
E866 45 58
E868 45
E869 C3      1383:          FCB   $C3
E86A E8 4B   1384:          FDB   QCOMP-8
E86C BD E655 1385: QEXEC    JSR   STATE
E86F BD E44E 1386:          JSR   AT
E872 BD E044 1387:          JSR   CLITER
E875 12      1388:          FCB   $12
E876 BD E83A 1389:          JSR   QERR
E879 39      1390:          RTS
             1391: *
E87A 86      1392:          FCB   $86
E87B 3F      1393:          FCC   "?PAIR"
E87C 50 41
E87E 49 52
E880 D3      1394:          FCB   $D3
E881 E8 64   1395:          FDB   QEXEC-8
E883 BD E707 1396: QPAIRS   JSR   SUB
E886 BD E044 1397:          JSR   CLITER
E889 13      1398:          FCB   $13
E88A BD E83A 1399:          JSR   QERR
E88D 39      1400:          RTS
             1401: *
E88E 84      1402:          FCB   $84
E88F 3F      1403:          FCC   "?CS"
E890 43 53
E892 D0      1404:          FCB   $D0
```

FORTH SSB MNEMONIC ASSEMBLER PAGE 27

```
E893 E8 7A    1405:          FDB   QPAIRS-9
E895 BD E307  1406: QCSP     JSR   SPAT
E898 BD E682  1407:          JSR   CSP
E89B BD E44E  1408:          JSR   AT
E89E BD E707  1409:          JSR   SUB
E8A1 BD E044  1410:          JSR   CLITER
E8A4 14       1411:          FCB   $14
E8A5 BD E83A  1412:          JSR   QERR
E8A8 39       1413:          RTS
              1414: *
E8A9 88       1415:          FCB   $88
E8AA 3F       1416:          FCC   "?LOADIN"
E8AB 4C 4F
E8AD 41 44
E8AF 49 4E
E8B1 C7       1417:          FCB   $C7
E8B2 E8 8E    1418:          FDB   QCSP-7
E8B4 BD E5FC  1419: QLOAD    JSR   BLK
E8B7 BD E44E  1420:          JSR   AT
E8BA BD E37B  1421:          JSR   ZEQU
E8BD BD E044  1422:          JSR   CLITER
E8C0 16       1423:          FCB   $16
E8C1 BD E83A  1424:          JSR   QERR
E8C4 39       1425:          RTS
              1426: *
E8C5 87       1427:          FCB   $87
E8C6 43       1428:          FCC   "COMPIL"
E8C7 4F 4D
E8C9 50 49
E8CB 4C
E8CC C5       1429:          FCB   $C5
E8CD E8 A9    1430:          FDB   QLOAD-11
E8CF BD E853  1431: COMPIL   JSR   QCOMP
E8D2 BD E358  1432:          JSR   FROMR
E8D5 BD E414  1433:          JSR   DUP
E8D8 BD E45E  1434:          JSR   CAT
E8DB BD E6F6  1435:          JSR   CCOMM
E8DE BD E6B0  1436:          JSR   ONEP
E8E1 BD E414  1437:          JSR   DUP
E8E4 BD E44E  1438:          JSR   AT
E8E7 BD E6E4  1439:          JSR   COMMA
E8EA BD E6BC  1440:          JSR   TWOP
E8ED BD E345  1441:          JSR   TOR
E8F0 39       1442:          RTS
              1443: *
E8F1 C1       1444:          FCB   $C1
E8F2 DB       1445:          FCB   $DB
E8F3 E8 C5    1446:          FDB   COMPIL-10
E8F5 BD E523  1447: LBRAK    JSR   ZERO
E8F8 BD E655  1448:          JSR   STATE
E8FB BD E46E  1449:          JSR   STORE
E8FE 39       1450:          RTS
              1451: *
E8FF 81       1452:          FCB   $81
E900 DD       1453:          FCB   $DD
E901 E8 F1    1454:          FDB   LBRAK-4
E903 BD E044  1455: RBRAK    JSR   CLITER
E906 C0       1456:          FCB   $C0
E907 BD E655  1457:          JSR   STATE
E90A BD E46E  1458:          JSR   STORE
```

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```
E90D 39       1459:          RTS
              1460: *
E90E 86       1461:          FCB   $86
E90F 53       1462:          FCC   "SMUDG"
E910 4D 55
E912 44 47
E914 C5       1463:          FCB   $C5
E915 E8 FF    1464:          FDB   RBRAK-4
E917 BD E7E0  1465: SMUDGE   JSR   LATEST
E91A BD E044  1466:          JSR   CLITER
E91D 20       1467:          FCB   $20
E91E BD E43A  1468:          JSR   TOGGLE
E921 39       1469:          RTS
              1470: *
E922 83       1471:          FCB   $83
E923 48       1472:          FCC   "HE"
E924 45
E925 D8       1473:          FCB   $D8
E926 E9 0E    1474:          FDB   SMUDGE-9
E928 BD E044  1475: HEX      JSR   CLITER
E92B 10       1476:          FCB   16
E92C BD E661  1477:          JSR   BASE
E92F BD E46E  1478:          JSR   STORE
E932 39       1479:          RTS
              1480: *
E933 87       1481:          FCB   $87
E934 44       1482:          FCC   "DECIMA"
E935 45 43
E937 49 4D
E939 41
E93A CC       1483:          FCB   $CC
E93B E9 22    1484:          FDB   HEX-6
E93D BD E044  1485: DEC      JSR   CLITER
E940 0A       1486:          FCB   10
E941 BD E661  1487:          JSR   BASE
E944 BD E46E  1488:          JSR   STORE
E947 39       1489:          RTS
              1490: *
E948 87       1491:          FCB   $87
E949 28       1492:          FCC   "(;CODE"
E94A 3B 43
E94C 4F 44
E94E 45
E94F A9       1493:          FCB   $A9
E950 E9 33    1494:          FDB   DEC-10
E952 BD E358  1495: PSCODE   JSR   FROMR
E955 BD E7E0  1496:          JSR   LATEST
E958 BD E813  1497:          JSR   PFA
E95B BD E044  1498:          JSR   CLITER
E95E BD       1499:          FCB   $BD
E95F BD EJE9  1500:          JSR   OVER
E962 BD E482  1501:          JSR   CSTORE
E965 BD E6B0  1502:          JSR   ONEP
E968 BD E46E  1503:          JSR   STORE
E96B 39       1504:          RTS
              1505: *
E96C C5       1506:          FCB   $C5
E96D 3B       1507:          FCC   ";COD"
E96E 43 4F
E970 44
```

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```
E971 C5       1508:          FCB   $C5
E972 E9 48    1509:          FDB   PSCODE-10
E974 BD E895  1510: SEMIC    JSR   QCSP
E977 BD E8CF  1511:          JSR   COMPIL
E97A BD E952  1512:          JSR   PSCODE
E97D BD E8F5  1513:          JSR   LBRAK
E980 BD EABE  1514:          JSR   QSTACK
E983 39       1515:          RTS
              1516: *
E984 87       1517:          FCB   $87
E985 3C       1518:          FCC   "<BUILD"
E986 42 55
E988 49 4C
E98A 44
E98B D3       1519:          FCB   $D3
E98C E9 6C    1520:          FDB   SEMIC-8
E98E BD E523  1521: BUILDS   JSR   ZERO
E991 BD E4CE  1522:          JSR   CON
E994 BD E52C  1523:          JSR   ONE
E997 BD E6D9  1524:          JSR   ALLOT
E99A 39       1525:          RTS
              1526: *
E99B 85       1527:          FCB   $85
E99C 44       1528:          FCC   "DOES"
E99D 4F 45
E99F 53
E9A0 BE       1529:          FCB   $BE
E9A1 E9 84    1530:          FDB   BUILDS-10
E9A3 BD E358  1531: DOES     JSR   FROMR
E9A6 BD E7E0  1532:          JSR   LATEST
E9A9 BD E813  1533:          JSR   PFA
E9AC BD E53E  1534:          JSR   THREE
E9AF BD E399  1535:          JSR   PLUS
E9B2 BD E044  1536:          JSR   CLITER
E9B5 7E       1537:          FCB   $7E
E9B6 BD E3E9  1538:          JSR   OVER
E9B9 BD E482  1539:          JSR   CSTORE
E9BC BD E6B0  1540:          JSR   ONEP
E9BF BD E46E  1541:          JSR   STORE
E9C2 BD E952  1542:          JSR   PSCODE
E9C5 BD E36A  1543: DODOES   JSR   R
E9C8 BD E53E  1544:          JSR   THREE
E9CB BD E399  1545:          JSR   PLUS
E9CE 39       1546:          RTS
              1547: *
E9CF 85       1548:          FCB   $85
E9D0 43       1549:          FCC   "COUN"
E9D1 4F 55
E9D3 4E
E9D4 D4       1550:          FCB   $D4
E9D5 E9 9B    1551:          FDB   DOES-8
E9D7 BD E414  1552: COUNT    JSR   DUP
E9DA BD E6B0  1553:          JSR   ONEP
E9DD BD E401  1554:          JSR   SWAP
E9E0 BD E45E  1555:          JSR   CAT
E9E3 39       1556:          RTS
              1557: *
E9E4 84       1558:          FCB   $84
E9E5 54       1559:          FCC   "TYP"
E9E6 59 50
```

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```
E9E8 C5       1560:          FCB   $C5
E9E9 E9 CF    1561:          FDB   COUNT-8
E9EB BD E79E 1562: TYPE      JSR   DDUP
E9EE BD E06E 1563:           JSR   ZBRAN
E9F1 27 23    1564:          BEQ   TYPE3
E9F3 BD E3E9 1565:           JSR   OVER
E9F6 BD E399 1566:           JSR   PLUS
E9F9 BD E401 1567:           JSR   SWAP
E9FC BD E0C1 1568:           JSR   XDO
E9FF BD E0DA 1569: TYPE2     JSR   I
EA02 BD E45E 1570:           JSR   CAT
EA05 BD E044 1571:           JSR   CLITER
EA08 7F       1572:          FCB   $7F
EA09 BD E2D5 1573:           JSR   AND
EA0C BD E1DC 1574:           JSR   EMIT
EA0F BD E07C 1575:           JSR   XLOOP
EA12 27 EB    1576:          BEQ   TYPE2
EA14 20 03    1577:          BRA   TYPE4
EA16 BD E3F7 1578: TYPE3     JSR   DROP
EA19 39       1579: TYPE4    RTS
              1580: *
EA1A 89       1581:          FCB   $89
EA1B 2D       1582:          FCC   "-TRAILIN"
EA1C 54 52
EA1E 41 49
EA20 4C 49
EA22 4E
EA23 C7       1583:          FCB   $C7
EA24 E9 E4    1584:          FDB   TYPE-7
EA26 BD E414 1585: DTRAIL    JSR   DUP
EA29 BD E523 1586:           JSR   ZERO
EA2C BD E0C1 1587:           JSR   XDO
EA2F BD E3E9 1588: DTRAL2    JSR   OVER
EA32 BD E3E9 1589:           JSR   OVER
EA35 BD E399 1590:           JSR   PLUS
EA38 BD E52C 1591:           JSR   ONE
EA3B BD E707 1592:           JSR   SUB
EA3E BD E45E 1593:           JSR   CAT
EA41 BD E548 1594:           JSR   BL
EA44 BD E707 1595:           JSR   SUB
EA47 BD E06E 1596:           JSR   ZBRAN
EA4A 27 05    1597:          BEQ   DTRAL3
EA4C BD E336 1598:           JSR   LEAVE
EA4F 20 06    1599:          BRA   DTRAL4
EA51 BD E52C 1600: DTRAL3    JSR   ONE
EA54 BD E707 1601:           JSR   SUB
EA57 BD E07C 1602: DTRAL4    JSR   XLOOP
EA5A 27 D3    1603:          BEQ   DTRAL2
EA5C 39       1604:          RTS
              1605: *
EA5D 84       1606:          FCB   $84
EA5E 28       1607:          FCC   /(."/
EA5F 2E 22
EA61 A9       1608:          FCB   $A9
EA62 EA 1A    1609:          FDB   DTRAIL-12
EA64 BD E36A 1610: PDOTQ     JSR   R
EA67 BD E9D7 1611:           JSR   COUNT
EA6A BD E414 1612:           JSR   DUP
EA6D BD E6B0 1613:           JSR   ONEP
EA70 BD E358 1614:           JSR   FROMR
```

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```
EA73 BD E399 1615:          JSR   PLUS
EA76 BD E345 1616:          JSR   TOR
EA79 BD E9EB 1617:          JSR   TYPE
EA7C 39      1618:          RTS
             1619: *
EA7D C2      1620:          FCB   $C2
EA7E 2E      1621:          FCC   "."
EA7F A2      1622:          FCB   $A2
EA80 EA 5D   1623:          FDB   PDOTQ-7
EA82 BD E044 1624: DOTQ     JSR   CLITER
EA85 22      1625:          FCB   $22
EA86 BD E655 1626:          JSR   STATE
EA89 BD E44E 1627:          JSR   AT
EA8C BD E06E 1628:          JSR   ZBRAN
EA8F 27 17   1629:          BEQ   DOTQ1
EA91 BD E8CF 1630:          JSR   COMPIL
EA94 BD EA64 1631:          JSR   PDOTQ
EA97 BD EC5C 1632:          JSR   WORD
EA9A BD E6CA 1633:          JSR   HERE
EA9D BD E45E 1634:          JSR   CAT
EAA0 BD E6B0 1635:          JSR   ONEP
EAA3 BD E6D9 1636:          JSR   ALLOT
EAA6 20 0C   1637:          BRA   DOTQ2
EAA8 BD EC5C 1638: DOTQ1    JSR   WORD
EAAB BD E6CA 1639:          JSR   HERE
EAAE BD E9D7 1640:          JSR   COUNT
EAB1 BD E9EB 1641:          JSR   TYPE
EAB4 39      1642: DOTQ2    RTS
             1643: *
EAB5 86      1644:          FCB   $86
EAB6 3F      1645:          FCC   "?STAC"
EAB7 53 54
EAB9 41 43
EABB CB      1646:          FCB   $CB
EABC EA 7D   1647:          FDB   DOTQ-5
EABE BD E044 1648: QSTACK   JSR   CLITER
EAC1 12      1649:          FCB   $12
EAC2 BD E58B 1650:          JSR   PORIG
EAC5 BD E44E 1651:          JSR   AT
EAC8 BD E52C 1652:          JSR   ONE
EACB BD E707 1653:          JSR   SUB
EACE BD E307 1654:          JSR   SPAT
EAD1 BD E71D 1655:          JSR   LESS
EAD4 BD E52C 1656:          JSR   ONE
EAD7 BD E83A 1657:          JSR   QERR
EADA BD E307 1658: QSTAC2   JSR   SPAT
EADD BD E02C 1659:          JSR   LIT
EAE0 D0 00   1660:          FDB   $D000
EAE2 BD E71D 1661:          JSR   LESS
EAE5 BD E06E 1662:          JSR   ZBRAN
EAE8 27 06   1663:          BEQ   QSTAC3
EAEA BD E535 1664:          JSR   TWO
EAED BD E83A 1665:          JSR   QERR
EAF0 39      1666: QSTAC3   RTS
             1667: *
EAF1 86      1668:          FCB   $86
EAF2 45      1669:          FCC   "EXPEC"
EAF3 58 50
EAF5 45 43
EAF7 D4      1670:          FCB   $D4
```

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```
EAF8 EA B5    1671:          FDB   QSTACK-9
EAFA BD E3E9 1672: EXPECT    JSR   OVER
EAFD BD E399 1673:           JSR   PLUS
EB00 BD E3E9 1674:           JSR   OVER
EB03 BD E0C1 1675:           JSR   XDO
EB06 BD E1F6 1676: EXPEC2    JSR   KEY
EB09 BD E414 1677:           JSR   DUP
EB0C BD E044 1678:           JSR   CLITER
EB0F 0E      1679:           FCB   $0E
EB10 BD E58B 1680:           JSR   PORIG
EB13 BD E44E 1681:           JSR   AT
EB16 BD E712 1682:           JSR   EQUAL
EB19 BD E06E 1683:           JSR   ZBRAN
EB1C 27 27   1684:           BEQ   EXPEC3
EB1E BD E3F7 1685:           JSR   DROP
EB21 BD E044 1686:           JSR   CLITER
EB24 08      1687:           FCB   8
EB25 BD E3E9 1688:           JSR   OVER
EB28 BD E0DA 1689:           JSR   I
EB2B BD E712 1690:           JSR   EQUAL
EB2E BD E414 1691:           JSR   DUP
EB31 BD E358 1692:           JSR   FROMR
EB34 BD E535 1693:           JSR   TWO
EB37 BD E707 1694:           JSR   SUB
EB3A BD E399 1695:           JSR   PLUS
EB3D BD E345 1696:           JSR   TOR
EB40 BD E707 1697:           JSR   SUB
EB43 20 32   1698:           BRA   EXPEC6
EB45 BD E414 1699: EXPEC3    JSR   DUP
EB48 BD E044 1700:           JSR   CLITER
EB4B 0D      1701:           FCB   $D
EB4C BD E712 1702:           JSR   EQUAL
EB4F BD E06E 1703:           JSR   ZBRAN
EB52 27 0E   1704:           BEQ   EXPEC4
EB54 BD E336 1705:           JSR   LEAVE
EB57 BD E3F7 1706:           JSR   DROP
EB5A BD E548 1707:           JSR   BL
EB5D BD E523 1708:           JSR   ZERO
EB60 20 03   1709:           BRA   EXPEC5
EB62 BD E414 1710: EXPEC4    JSR   DUP
EB65 BD E0DA 1711: EXPEC5    JSR   I
EB68 BD E482 1712:           JSR   CSTORE
EB6B BD E523 1713:           JSR   ZERO
EB6E BD E0DA 1714:           JSR   I
EB71 BD E6B0 1715:           JSR   ONEP
EB74 BD E46E 1716:           JSR   STORE
EB77 BD E1DC 1717: EXPEC6    JSR   EMIT
EB7A BD E07C 1718:           JSR   XLOOP
EB7D 27 87   1719:           BEQ   EXPEC2
EB7F BD E3F7 1720:           JSR   DROP
EB82 39      1721:           RTS
             1722: *
EB83 85      1723:           FCB   $85
EB84 51      1724:           FCC   "QUER"
EB85 55 45
EB87 52
EB88 D9      1725:           FCB   $D9
EB89 EA F1   1726:           FDB   EXPECT-9
EB8B BD E5AE 1727: QUERY     JSR   TIB
EB8E BD E44E 1728:           JSR   AT
```

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```
EB91 BD E6A6 1729:          JSR   COLUMS
EB94 BD E44E 1730:          JSR   AT
EB97 BD EAFA 1731:          JSR   EXPECT
EB9A BD E523 1732:          JSR   ZERO
EB9D BD E606 1733:          JSR   IN
EBA0 BD E46E 1734:          JSR   STORE
EBA3 39      1735:          RTS
             1736: *
EBA4 C1      1737:          FCB   $C1
EBA5 80      1738:          FCB   $80
EBA6 EB 83   1739:          FDB   QUERY-8
EBA8 BD E5FC 1740: NULL     JSR   BLK
EBAB BD E44E 1741:          JSR   AT
EBAE BD E06E 1742:          JSR   ZBRAN
EBB1 27 29   1743:          BEQ   NULL2
EBB3 BD E52C 1744:          JSR   ONE
EBB6 BD E5FC 1745:          JSR   BLK
EBB9 BD E420 1746:          JSR   PSTORE
EBBC BD E523 1747:          JSR   ZERO
EBBF BD E606 1748:          JSR   IN
EBC2 BD E46E 1749:          JSR   STORE
EBC5 BD E5FC 1750:          JSR   BLK
EBC8 BD E44E 1751:          JSR   AT
EBCB BD E57C 1752:          JSR   BSCR
EBCE BD F185 1753:          JSR   MOD
EBD1 BD E37B 1754:          JSR   ZEQU
EBD4 BD E06E 1755:          JSR   ZBRAN
EBD7 27 09   1756:          BEQ   NULL3
EBD9 BD E86C 1757:          JSR   QEXEC
EBDC BD E358 1758: NULL2    JSR   FROMR
EBDF BD E3F7 1759:          JSR   DROP
EBE2 39      1760: NULL3    RTS
             1761: *
EBE3 84      1762:          FCB   $84
EBE4 46      1763:          FCC   "FIL"
EBE5 49 4C
EBE7 CC      1764:          FCB   $CC
EBE8 EB A4   1765:          FDB   NULL-4
EBEA BD E401 1766: FILL     JSR   SWAP
EBED BD E345 1767:          JSR   TOR
EBF0 BD E3E9 1768:          JSR   OVER
EBF3 BD E482 1769:          JSR   CSTORE
EBF6 BD E414 1770:          JSR   DUP
EBF9 BD E6B0 1771:          JSR   ONEP
EBFC BD E358 1772:          JSR   FROMR
EBFF BD E52C 1773:          JSR   ONE
EC02 BD E707 1774:          JSR   SUB
EC05 BD E22D 1775:          JSR   CMOVE
EC08 39      1776:          RTS
             1777: *
EC09 85      1778:          FCB   $85
EC0A 45      1779:          FCC   "ERAS"
EC0B 52 41
EC0D 53
EC0E C5      1780:          FCB   $C5
EC0F EB E3   1781:          FDB   FILL-7
EC11 BD E523 1782: ERASE    JSR   ZERO
EC14 BD EBEA 1783:          JSR   FILL
EC17 39      1784:          RTS
             1785: *
```

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```
EC18 86       1786:          FCB   $86
EC19 42       1787:          FCC   "BLANK"
EC1A 4C 41
EC1C 4E 4B
EC1E D3       1788:          FCB   $D3
EC1F EC 09    1789:          FDB   ERASE-8
EC21 BD E548  1790: BLANKS   JSR   BL
EC24 BD EBEA  1791:          JSR   FILL
EC27 39       1792:          RTS
              1793: *
EC28 84       1794:          FCB   $84
EC29 48       1795:          FCC   "HOL"
EC2A 4F 4C
EC2C C4       1796:          FCB   $C4
EC2D EC 18    1797:          FDB   BLANKS-9
EC2F BD E02C  1798: HOLD     JSR   LIT
EC32 FF FF    1799:          FDB   $FFFF
EC34 BD E697  1800:          JSR   HLD
EC37 BD E420  1801:          JSR   PSTORE
EC3A BD E697  1802:          JSR   HLD
EC3D BD E44E  1803:          JSR   AT
EC40 BD E482  1804:          JSR   CSTORE
EC43 39       1805:          RTS
              1806: *
EC44 83       1807:          FCB   $83
EC45 50       1808:          FCC   "PA"
EC46 41
EC47 C4       1809:          FCB   $C4
EC48 EC 28    1810:          FDB   HOLD-7
EC4A BD E6CA  1811: PAD      JSR   HERE
EC4D BD E044  1812:          JSR   CLITER
EC50 44       1813:          FCB   $44
EC51 BD E399  1814:          JSR   PLUS
EC54 39       1815:          RTS
              1816: *
EC55 84       1817:          FCB   $84
EC56 57       1818:          FCC   "WOR"
EC57 4F 52
EC59 C4       1819:          FCB   $C4
EC5A EC 44    1820:          FDB   PAD-6
EC5C BD E5FC  1821: WORD     JSR   BLK
EC5F BD E44E  1822:          JSR   AT
EC62 BD E06E  1823:          JSR   ZBRAN
EC65 27 0B    1824:          BEQ   WORD2
EC67 BD E5FC  1825:          JSR   BLK
EC6A BD E44E  1826:          JSR   AT
EC6D BD F314  1827:          JSR   BLOCK
EC70 20 06    1828:          BRA   WORD3
EC72 BD E5AE  1829: WORD2    JSR   TIB
EC75 BD E44E  1830:          JSR   AT
EC78 BD E606  1831: WORD3    JSR   IN
EC7B BD E44E  1832:          JSR   AT
EC7E BD E399  1833:          JSR   PLUS
EC81 BD E401  1834:          JSR   SWAP
EC84 BD E18A  1835:          JSR   ENCLOS
EC87 BD E6CA  1836:          JSR   HERE
EC8A BD E044  1837:          JSR   CLITER
EC8D 22       1838:          FCB   34
EC8E BD EC21  1839:          JSR   BLANKS
EC91 BD E606  1840:          JSR   IN
```

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```
EC94 BD E420 1841:          JSR   PSTORE
EC97 BD E3E9 1842:          JSR   OVER
EC9A BD E707 1843:          JSR   SUB
EC9D BD E345 1844:          JSR   TOR
ECA0 BD E36A 1845:          JSR   R
ECA3 BD E6CA 1846:          JSR   HERE
ECA6 BD E482 1847:          JSR   CSTORE
ECA9 BD E399 1848:          JSR   PLUS
ECAC BD E6CA 1849:          JSR   HERE
ECAF BD E6B0 1850:          JSR   ONEP
ECB2 BD E358 1851:          JSR   FROMR
ECB5 BD E22D 1852:          JSR   CMOVE
ECB8 39      1853:          RTS
             1854: *
ECB9 88      1855:          FCB   $88
ECBA 28      1856:          FCC   "(NUMBER"
ECBB 4E 55
ECBD 4D 42
ECBF 45 52
ECC1 A9      1857:          FCB   $A9
ECC2 EC 55   1858:          FDB   WORD-7
ECC4 BD E6B0 1859: PNUMB    JSR   ONEP
ECC7 BD E414 1860:          JSR   DUP
ECCA BD E345 1861:          JSR   TOR
ECCD BD E45E 1862:          JSR   CAT
ECD0 BD E661 1863:          JSR   BASE
ECD3 BD E44E 1864:          JSR   AT
ECD6 BD E0EE 1865:          JSR   DIGIT
ECD9 BD E06E 1866:          JSR   ZBRAN
ECDC 27 3A   1867:          BEQ   PNUMB4
ECDE BD E401 1868:          JSR   SWAP
ECE1 BD E661 1869:          JSR   BASE
ECE4 BD E44E 1870:          JSR   AT
ECE7 BD E262 1871:          JSR   USTAR
ECEA BD E3F7 1872:          JSR   DROP
ECED BD E745 1873:          JSR   ROT
ECF0 BD E661 1874:          JSR   BASE
ECF3 BD E44E 1875:          JSR   AT
ECF6 BD E262 1876:          JSR   USTAR
ECF9 BD E3A7 1877:          JSR   DPLUS
ECFC BD E66C 1878:          JSR   DPL
ECFF BD E44E 1879:          JSR   AT
ED02 BD E6B0 1880:          JSR   ONEP
ED05 BD E06E 1881:          JSR   ZBRAN
ED08 27 09   1882:          BEQ   PNUMB3
ED0A BD E52C 1883:          JSR   ONE
ED0D BD E66C 1884:          JSR   DPL
ED10 BD E420 1885:          JSR   PSTORE
ED13 BD E358 1886: PNUMB3   JSR   FROMR
ED16 20 AC   1887:          BRA   PNUMB
ED18 BD E358 1888: PNUMB4   JSR   FROMR
ED1B 39      1889:          RTS
             1890: *
ED1C 86      1891:          FCB   $86
ED1D 4E      1892:          FCC   "NUMBE"
ED1E 55 4D
ED20 42 45
ED22 D2      1893:          FCB   $D2
ED23 EC B9   1894:          FDB   PNUMB-11
ED25 BD E523 1895: NUMB     JSR   ZERO
```

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```
ED28 BD E523 1896:          JSR   ZERO
ED2B BD E745 1897:          JSR   ROT
ED2E BD E414 1898:          JSR   DUP
ED31 BD E6B0 1899:          JSR   ONEP
ED34 BD E45E 1900:          JSR   CAT
ED37 BD E044 1901:          JSR   CLITER
ED3A 2D      1902:          FCC   "-"
ED3B BD E712 1903:          JSR   EQUAL
ED3E BD E414 1904:          JSR   DUP
ED41 BD E345 1905:          JSR   TOR
ED44 BD E399 1906:          JSR   PLUS
ED47 BD E02C 1907:          JSR   LIT
ED4A FF FF   1908:          FDB   $FFFF
ED4C BD E66C 1909: NUMB1    JSR   DPL
ED4F BD E46E 1910:          JSR   STORE
ED52 BD ECC4 1911:          JSR   PNUMB
ED55 BD E414 1912:          JSR   DUP
ED58 BD E45E 1913:          JSR   CAT
ED5B BD E548 1914:          JSR   BL
ED5E BD E707 1915:          JSR   SUB
ED61 BD E06E 1916:          JSR   ZBRAN
ED64 27 18   1917:          BEQ   NUMB2
ED66 BD E414 1918:          JSR   DUP
ED69 BD E45E 1919:          JSR   CAT
ED6C BD E044 1920:          JSR   CLITER
ED6F 2E      1921:          FCC   "."
ED70 BD E707 1922:          JSR   SUB
ED73 BD E523 1923:          JSR   ZERO
ED76 BD E83A 1924:          JSR   QERR
ED79 BD E523 1925:          JSR   ZERO
ED7C 20 CE   1926:          BRA   NUMB1
ED7E BD E3F7 1927: NUMB2    JSR   DROP
ED81 BD E358 1928:          JSR   FROMR
ED84 BD E06E 1929:          JSR   ZBRAN
ED87 27 03   1930:          BEQ   NUMB3
ED89 BD E3D2 1931:          JSR   DMINUS
ED8C 39      1932: NUMB3    RTS
             1933: *
ED8D 85      1934:          FCB   $85
ED8E 2D      1935:          FCC   "-FIN"
ED8F 46 49
ED91 4E
ED92 C4      1936:          FCB   $C4
ED93 ED 1C   1937:          FDB   NUMB-9
ED95 BD E548 1938: DFIND    JSR   BL
ED98 BD EC5C 1939:          JSR   WORD
ED9B BD E6CA 1940:          JSR   HERE
ED9E BD E639 1941:          JSR   CONTXT
EDA1 BD E44E 1942:          JSR   AT
EDA4 BD E44E 1943:          JSR   AT
EDA7 BD E11D 1944:          JSR   PFIND
EDAA BD E414 1945:          JSR   DUP
EDAD BD E37B 1946:          JSR   ZEQU
EDB0 BD E06E 1947:          JSR   ZBRAN
EDB3 27 0C   1948:          BEQ   DFIND2
EDB5 BD E3F7 1949:          JSR   DROP
EDB8 BD E6CA 1950:          JSR   HERE
EDBB BD E7E0 1951:          JSR   LATEST
EDBE BD E11D 1952:          JSR   PFIND
EDC1 39      1953: DFIND2   RTS
```

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```
                    1954: *
EDC2 87             1955:          FCB   $87
EDC3 28             1956:          FCC   "(ABORT"
EDC4 41 42
EDC6 4F 52
EDC8 54
EDC9 A9             1957:          FCB   $A9
EDCA ED 8D          1958:          FDB   DFIND-8
EDCC BD F055        1959: PABORT   JSR   ABORT
EDCF 39             1960:          RTS
                    1961: *
EDD0 85             1962:          FCB   $85
EDD1 45             1963:          FCC   "ERRO"
EDD2 52 52
EDD4 4F
EDD5 D2             1964:          FCB   $D2
EDD6 ED C2          1965:          FDB   PABORT-10
EDD8 BD E5CA        1966: ERROR    JSR   WARN
EDDB BD E44E        1967:          JSR   AT
EDDE BD E38B        1968:          JSR   ZLESS
EDE1 BD E06E        1969:          JSR   ZBRAN
EDE4 27 03          1970:          BEQ   ERROR2
EDE6 BD EDCC        1971:          JSR   PABORT
EDE9 BD E6CA        1972: ERROR2   JSR   HERE
EDEC BD E9D7        1973:          JSR   COUNT
EDEF BD E9EB        1974:          JSR   TYPE
EDF2 BD EA64        1975:          JSR   PDOTQ
EDF5 04             1976:          FCB   4,7
EDF6 07
EDF7 20             1977:          FCC   " ? "
EDF8 3F 20
EDFA BD F3D9        1978:          JSR   MESS
EDFD BD E312        1979:          JSR   SPSTOR
EE00 BD E606        1980:          JSR   IN
EE03 BD E44E        1981:          JSR   AT
EE06 BD E5FC        1982:          JSR   BLK
EE09 BD E44E        1983:          JSR   AT
EE0C BD F00A        1984:          JSR   QUIT
EE0F 39             1985:          RTS
                    1986: *
EE10 83             1987:          FCB   $83
EE11 49             1988:          FCC   "ID"
EE12 44
EE13 AE             1989:          FCB   $AE
EE14 ED D0          1990:          FDB   ERROR-8
EE16 BD EC4A        1991: IDDOT    JSR   PAD
EE19 BD E044        1992:          JSR   CLITER
EE1C 20             1993:          FCB   32
EE1D BD E044        1994:          JSR   CLITER
EE20 5F             1995:          FCB   $5F
EE21 BD EBEA        1996:          JSR   FILL
EE24 BD E414        1997:          JSR   DUP
EE27 BD E813        1998:          JSR   PFA
EE2A BD E7F0        1999:          JSR   LFA
EE2D BD E3E9        2000:          JSR   OVER
EE30 BD E707        2001:          JSR   SUB
EE33 BD EC4A        2002:          JSR   PAD
EE36 BD E401        2003:          JSR   SWAP
EE39 BD E22D        2004:          JSR   CMOVE
EE3C BD EC4A        2005:          JSR   PAD
```

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```
EE3F BD E9D7 2006:          JSR   COUNT
EE42 BD E044 2007:          JSR   CLITER
EE45 1F      2008:          FCB   31
EE46 BD E2D5 2009:          JSR   AND
EE49 BD E9EB 2010:          JSR   TYPE
EE4C BD E75A 2011:          JSR   SPACE
EE4F 39      2012:          RTS
             2013: *
EE50 86      2014:          FCB   $86
EE51 43      2015:          FCC   "CREAT"
EE52 52 45
EE54 41 54
EE56 C5      2016:          FCB   $C5
EE57 EE 10   2017:          FDB   IDDOT-6
EE59 BD ED95 2018: CREATE   JSR   DFIND
EE5C BD E06E 2019:          JSR   ZBRAN
EE5F 27 1F   2020:          BEQ   CREAT2
EE61 BD E3F7 2021:          JSR   DROP
EE64 BD EA64 2022:          JSR   PDOTQ
EE67 08      2023:          FCB   8
EE68 07      2024:          FCB   7
EE69 72      2025:          FCC   "redef: "
EE6A 65 64
EE6C 65 66
EE6E 3A 20
EE70 BD E7FD 2026:          JSR   NFA
EE73 BD EE16 2027:          JSR   IDDOT
EE76 BD E044 2028:          JSR   CLITER
EE79 04      2029:          FCB   4
EE7A BD F3D9 2030:          JSR   MESS
EE7D BD E75A 2031:          JSR   SPACE
EE80 BD E6CA 2032: CREAT2   JSR   HERE
EE83 BD E414 2033:          JSR   DUP
EE86 BD E45E 2034:          JSR   CAT
EE89 BD E5BB 2035:          JSR   WIDTH
EE8C BD E44E 2036:          JSR   AT
EE8F BD E767 2037:          JSR   MIN
EE92 BD E6B0 2038:          JSR   ONEP
EE95 BD E6D9 2039:          JSR   ALLOT
EE98 BD E414 2040:          JSR   DUP
EE9B BD E044 2041:          JSR   CLITER
EE9E A0      2042:          FCB   $A0
EE9F BD E43A 2043:          JSR   TOGGLE
EEA2 BD E6CA 2044:          JSR   HERE
EEA5 BD E52C 2045:          JSR   ONE
EEA8 BD E707 2046:          JSR   SUB
EEAB BD E044 2047:          JSR   CLITER
EEAE 80      2048:          FCB   $80
EEAF BD E43A 2049:          JSR   TOGGLE
EEB2 BD E7E0 2050:          JSR   LATEST
EEB5 BD E6E4 2051:          JSR   COMMA
EEB8 BD E648 2052:          JSR   CURENT
EEBB BD E44E 2053:          JSR   AT
EEBE BD E46E 2054:          JSR   STORE
EEC1 39      2055:          RTS
             2056: *
EEC2 C9      2057:          FCB   $C9
EEC3 5B      2058:          FCC   "[COMPILE"
EEC4 43 4F
EEC6 4D 50
```

```
EEC8 49 4C
EECA 45
EECB DD       2059:          FCB   $DD
EECC EE 50    2060:          FDB   CREATE-9
EECE BD ED95  2061: BCOMP    JSR   DFIND
EED1 BD E37B  2062:          JSR   ZEQU
EED4 BD E523  2063:          JSR   ZERO
EED7 BD E83A  2064:          JSR   QERR
EEDA BD E3F7  2065:          JSR   DROP
EEDD BD E044  2066:          JSR   CLITER
EEE0 BD       2067:          FCB   $BD
EEE1 BD E6F6  2068:          JSR   CCOMM
EEE4 BD E6E4  2069:          JSR   COMMA
EEE7 39       2070:          RTS
              2071: *
EEE8 C7       2072:          FCB   $C7
EEE9 4C       2073:          FCC   "LITERA"
EEEA 49 54
EEEC 45 52
EEEE 41
EEEF CC       2074:          FCB   $CC
EEF0 EE C2    2075:          FDB   BCOMP-12
EEF2 BD E655  2076: LITER    JSR   STATE
EEF5 BD E44E  2077:          JSR   AT
EEF8 BD E06E  2078:          JSR   ZBRAN
EEFB 27 09    2079:          BEQ   LITER2
EEFD BD E8CF  2080:          JSR   COMPIL
EF00 BD E02C  2081:          JSR   LIT
EF03 BD E6E4  2082:          JSR   COMMA
EF06 39       2083: LITER2 RTS
              2084: *
EF07 C8       2085:          FCB   $C8
EF08 44       2086:          FCC   "DLITERA"
EF09 4C 49
EF0B 54 45
EF0D 52 41
EF0F CC       2087:          FCB   $CC
EF10 EE E8    2088:          FDB   LITER-10
EF12 BD E655  2089: DLITER   JSR   STATE
EF15 BD E44E  2090:          JSR   AT
EF18 BD E06E  2091:          JSR   ZBRAN
EF1B 27 09    2092:          BEQ   DLITE2
EF1D BD E401  2093:          JSR   SWAP
EF20 BD EEF2  2094:          JSR   LITER
EF23 BD EEF2  2095:          JSR   LITER
EF26 39       2096: DLITE2 RTS
              2097: *
EF27 89       2098:          FCB   $89
EF28 49       2099:          FCC   "INTERPRE"
EF29 4E 54
EF2B 45 52
EF2D 50 52
EF2F 45
EF30 D4       2100:          FCB   $D4
EF31 EF 07    2101:          FDB   DLITER-11
EF33 BD ED95  2102: INTERP   JSR   DFIND
EF36 BD E06E  2103:          JSR   ZBRAN
EF39 27 1F    2104:          BEQ   INTER5
EF3B BD E655  2105:          JSR   STATE
EF3E BD E44E  2106:          JSR   AT
```

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```
EF41 BD E71D 2107:          JSR   LESS
EF44 BD E06E 2108:          JSR   ZBRAN
EF47 27 0C   2109:          BEQ   INTER3
EF49 BD E044 2110:          JSR   CLITER
EF4C BD      2111:          FCB   $BD
EF4D BD E6F6 2112:          JSR   CCOMM
EF50 BD E6E4 2113:          JSR   COMMA
EF53 20 24   2114:          BRA   INTER7
EF55 BD E05D 2115: INTER3   JSR   EXEC
EF58 20 1F   2116: INTER4   BRA   INTER7
EF5A BD E6CA 2117: INTER5   JSR   HERE
EF5D BD ED25 2118:          JSR   NUMB
EF60 BD E66C 2119:          JSR   DPL
EF63 BD E44E 2120:          JSR   AT
EF66 BD E6B0 2121:          JSR   ONEP
EF69 BD E06E 2122:          JSR   ZBRAN
EF6C 27 05   2123:          BEQ   INTER6
EF6E BD EF12 2124:          JSR   DLITER
EF71 20 06   2125:          BRA   INTER7
EF73 BD E3F7 2126: INTER6   JSR   DROP
EF76 BD EEF2 2127:          JSR   LITER
EF79 BD EABE 2128: INTER7   JSR   QSTACK
EF7C 20 B5   2129:          BRA   INTERP
EF7E 39      2130:          RTS
             2131: *
EF7F 89      2132:          FCB   $89
EF80 49      2133:          FCC   "IMMEDIAT"
EF81 4D 4D
EF83 45 44
EF85 49 41
EF87 54
EF88 C5      2134:          FCB   $C5
EF89 EF 27   2135:          FDB   INTERP-12
EF8B BD E7E0 2136: IMMED    JSR   LATEST
EF8E BD E044 2137:          JSR   CLITER
EF91 40      2138:          FCB   $40
EF92 BD E43A 2139:          JSR   TOGGLE
EF95 39      2140:          RTS
             2141: *
EF96 8A      2142:          FCB   $8A
EF97 56      2143:          FCC   "VOCABULAR"
EF98 4F 43
EF9A 41 42
EF9C 55 4C
EF9E 41 52
EFA0 D9      2144:          FCB   $D9
EFA1 EF 7F   2145:          FDB   IMMED-12
EFA3 BD E98E 2146: VOCAB    JSR   BUILDS
EFA6 BD E02C 2147:          JSR   LIT
EFA9 81 A0   2148:          FDB   $81A0
EFAB BD E6E4 2149:          JSR   COMMA
EFAE BD E648 2150:          JSR   CURENT
EFB1 BD E44E 2151:          JSR   AT
EFB4 BD E535 2152:          JSR   TWO
EFB7 BD E707 2153:          JSR   SUB
EFBA BD E6E4 2154:          JSR   COMMA
EFBD BD E6CA 2155:          JSR   HERE
EFC0 BD E5F1 2156:          JSR   VOCLIN
EFC3 BD E44E 2157:          JSR   AT
EFC6 BD E6E4 2158:          JSR   COMMA
```

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```
EFC9 BD E5F1 2159:          JSR . VOCLIN
EFCC BD E46E 2160:          JSR   STORE
EFCF BD E9A3 2161:          JSR   DOES
EFD2 BD E6BC 2162: DOVOC    JSR   TWOP
EFD5 BD E639 2163:          JSR   CONTXT
EFD8 BD E46E 2164:          JSR   STORE
EFDB 39      2165:          RTS
             2166: *
EFDC 8B      2167:          FCB   $8B
EFDD 44      2168:          FCC   "DEFINITION"
EFDE 45 46
EFE0 49 4E
EFE2 49 54
EFE4 49 4F
EFE6 4E
EFE7 D3      2169:          FCB   $D3
EFE8 EF 96   2170:          FDB   VOCAB-13
EFEA BD E639 2171: DEFIN    JSR   CONTXT
EFED BD E44E 2172:          JSR   AT
EFF0 BD E648 2173:          JSR   CURENT
EFF3 BD E46E 2174:          JSR   STORE
EFF6 39      2175:          RTS
             2176: *
EFF7 C1      2177:          FCB   $C1
EFF8 A8      2178:          FCB   $A8
EFF9 EF DC   2179:          FDB   DEFIN-14
EFFB BD E044 2180: PAREN    JSR   CLITER
EFFE 29      2181:          FCC   ")"
EFFF BD EC5C 2182:          JSR   WORD
F002 39      2183:          RTS
             2184: *
F003 84      2185:          FCB   $84
F004 51      2186:          FCC   "QUI"
F005 55 49
F007 D4      2187:          FCB   $D4
F008 EF F7   2188:          FDB   PAREN-4
F00A BD E523 2189: QUIT     JSR   ZERO
F00D BD E5FC 2190:          JSR   BLK
F010 BD E46E 2191:          JSR   STORE
F013 BD E8F5 2192:          JSR   LBRAK
F016 BD E31D 2193: QUIT2    JSR   RPSTOR
F019 BD E21D 2194:          JSR   CR
F01C BD EB8B 2195:          JSR   QUERY
F01F BD EF33 2196:          JSR   INTERP
F022 BD E655 2197:          JSR   STATE
F025 BD E44E 2198:          JSR   AT
F028 BD E37B 2199:          JSR   ZEQU
F02B BD E06E 2200:          JSR   ZBRAN
F02E 27 E6   2201:          BEQ   QUIT2
F030 BD E535 2202:          JSR   TWO
F033 BD E45E 2203:          JSR   CAT
F036 BD E044 2204:          JSR   CLITER
F039 BF      2205:          FCB   $BF
F03A BD E2D5 2206:          JSR   AND
F03D BD E535 2207:          JSR   TWO
F040 BD E482 2208:          JSR   CSTORE
F043 BD EA64 2209:          JSR   PDOTQ
F046 03      2210:          FCB   3
F047 20      2211:          FCC   " OK"
F048 4F 4B
```

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```
F04A 20 CA    2212: QUIT3  BRA   QUIT2
F04C 39       2213:        RTS
              2214: *
F04D 85       2215:        FCB   $85
F04E 41       2216:        FCC   "ABOR"
F04F 42 4F
F051 52
F052 D4       2217:        FCB   $D4
F053 F0 03    2218:        FDB   QUIT-7
F055 BD E312  2219: ABORT  JSR   SPSTOR
F058 BD E93D  2220:        JSR   DEC
F05B BD EABE  2221:        JSR   QSTACK
F05E BD F28F  2222:        JSR   DRZERO
F061 BD E21D  2223:        JSR   CR
F064 BD EA64  2224:        JSR   PDOTQ
F067 08       2225:        FCB   8
F068 46       2226:        FCC   "Forth-84"
F069 6F 72
F06B 74 68
F06D 2D 38
F06F 34
F070 BD 2008  2227:        JSR   FORTH
F073 BD EFEA  2228:        JSR   DEFIN
F076 BD F00A  2229:        JSR   QUIT
F079 39       2230:        RTS
              2231: *
F07A 84       2232:        FCB   $84
F07B 43       2233:        FCC   "COL"
F07C 4F 4C
F07E C4       2234:        FCB   $C4
F07F F0 4D    2235:        FDB   ABORT-8
F081          2236: COLD   EQU   *
F081 8E 2034  2237: CENT   LDS   #REND-1
F084 CE F133  2238:        LDX   #ERAM
F087 09       2239: COLD2  DEX
F088 A6 00    2240:        LDA A 0,X
F08A 36       2241:        PSH A
F08B 8C F0FE  2242:        CPX   #RFORTH-8
F08E 26 F7    2243:        BNE   COLD2
F090 8E 00DE  2244:        LDS   #N-2
F093 CE F0FE  2245:        LDX   #JMPTAB+15
F096 09       2246: COLD3  DEX
F097 A6 00    2247:        LDA A 0,X
F099 36       2248:        PSH A
F09A 8C F0EF  2249:        CPX   #JMPTAB
F09D 26 F7    2250:        BNE   COLD3
F09F 8E 400F  2251:        LDS   #XFENCE-1
F0A2 FE E022  2252:        LDX   COLINT
F0A5 FF 4034  2253:        STX   XCOLUM
F0A8 FE E024  2254:        LDX   DELINT
F0AB FF 4032  2255:        STX   XDELAY
F0AE FE E020  2256:        LDX   VOCINT
F0B1 FF 4014  2257:        STX   XVOCL
F0B4 FE E01E  2258:        LDX   DPINIT
F0B7 FF 4012  2259:        STX   XDP
F0BA FE E01C  2260:        LDX   FENCIN
F0BD FF 4010  2261:        STX   XFENCE
F0C0 CE DDE0  2262:        LDX   #$DDE0
F0C3 FF 4040  2263:        STX   XUSE
F0C6 FF 4042  2264:        STX   XPREV
```

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```
F0C9 8E 400F 2265: WENT   LDS   #XFENCE-1
F0CC CE E01C 2266:        LDX   #FENCIN
F0CF 09      2267: WARM2  DEX
F0D0 A6 00   2268:        LDA A 0,X
F0D2 36      2269:        PSH A
F0D3 8C E012 2270:        CPX   #SINIT
F0D6 26 F7   2271:        BNE   WARM2
F0D8 BE E014 2272:        LDS   RINIT
F0DB FE E010 2273:        LDX   UPINIT
F0DE DF F2   2274:        STX   UP
F0E0 CE F055 2275:        LDX   #ABORT
F0E3 3C      2276:        FCB   $3C          PSHX
F0E4 86 00   2277:        LDA A #0
F0E6 97 02   2278:        STA A 02
F0E8 86 40   2279:        LDA A #$40
F0EA 97 00   2280:        STA A 00
F0EC 7E E31D 2281:        JMP   RPSTOR
F0EF 7E FF95 2282: JMPTAB JMP   TRAP
F0F2 7E FF95 2283:        JMP   TRAP
F0F5 7E FF95 2284:        JMP   TRAP
F0F8 7E FF95 2285:        JMP   TRAP
F0FB 7E FF95 2286:        JMP   TRAP
             2287: *
F0FE C5      2288:        FCB   $C5
F0FF 46      2289:        FCC   "FORT"
F100 4F 52
F102 54
F103 C8      2290:        FCB   $C8
F104 FD D0   2291:        FDB   NOOP-7
F106 BD E9C5 2292: RFORTH JSR   DODOES
F109 7E EFD2 2293:        JMP   DOVOC
F10C 81 A0   2294:        FDB   $81A0
F10E 20 2D   2295:        FDB   TASK-7
F110 00 00   2296:        FDB   0
F112 54      2297:        FCC   "Turbo-Forth for 6303 1984"
F113 75 72
F115 62 6F
F117 2D 46
F119 6F 72
F11B 74 68
F11D 20 66
F11F 6F 72
F121 20 36
F123 33 30
F125 33 20
F127 31 39
F129 38 34
F12B 84      2298:        FCB   $84
F12C 54      2299:        FCC   "TAS"
F12D 41 53
F12F CB      2300:        FCB   $CB
F130 20 00   2301:        FDB   FORTH-8
F132 39      2302: RTASK  RTS
F133 43      2303: ERAM   FCC   "Chris Flewellen"
F134 68 72
F136 69 73
F138 20 46
F13A 6C 65
F13C 77 65
F13E 6C 6C
```

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```
F140 65 6E
F142 84       2304:          FCB   $84
F143 53       2305:          FCC   "S->"
F144 2D 3E
F146 C4       2306:          FCB   $C4
F147 F0 7A    2307:          FDB   COLD-7
F149 BD E414  2308: STOD     JSR   DUP
F14C BD E38B  2309:          JSR   ZLESS
F14F BD E3C2  2310:          JSR   MINUS
F152 39       2311:          RTS
              2312: *
F153 81       2313:          FCB   $81
F154 AA       2314:          FCB   $AA
F155 F1 42    2315:          FDB   STOD-7
F157 BD E262  2316: STAR     JSR   USTAR
F15A 08       2317:          INX
F15B 08       2318:          INX
F15C 39       2319:          RTS
              2320: *
F15D 84       2321:          FCB   $84
F15E 2F       2322:          FCC   "/MO"
F15F 4D 4F
F161 C4       2323:          FCB   $C4
F162 F1 53    2324:          FDB   STAR-4
F164 BD E345  2325: SLMOD    JSR   TOR
F167 BD F149  2326:          JSR   STOD
F16A BD E358  2327:          JSR   FROMR
F16D BD F9BC  2328:          JSR   MSLASH
F170 39       2329:          RTS
              2330: *
F171 81       2331:          FCB   $81
F172 AF       2332:          FCB   $AF
F173 F1 5D    2333:          FDB   SLMOD-7
F175 BD F164  2334: SLASH    JSR   SLMOD
F178 BD E401  2335:          JSR   SWAP
F17B BD E3F7  2336:          JSR   DROP
F17E 39       2337:          RTS
              2338: *
F17F 83       2339:          FCB   $83
F180 4D       2340:          FCC   "MO"
F181 4F
F182 C4       2341:          FCB   $C4
F183 F1 71    2342:          FDB   SLASH-4
F185 BD F164  2343: MOD      JSR   SLMOD
F188 BD E3F7  2344:          JSR   DROP
F18B 39       2345:          RTS
              2346: *
F18C 85       2347:          FCB   $85
F18D 2A       2348:          FCC   "*/MO"
F18E 2F 4D
F190 4F
F191 C4       2349:          FCB   $C4
F192 F1 7F    2350:          FDB   MOD-6
F194 BD E345  2351: SSMOD    JSR   TOR
F197 BD F998  2352:          JSR   MSTAR
F19A BD E358  2353:          JSR   FROMR
F19D BD F9BC  2354:          JSR   MSLASH
F1A0 39       2355:          RTS
              2356: *
F1A1 82       2357:          FCB   $82
```

```
F1A2 2A       2358:          FCC   "*"
F1A3 AF       2359:          FCB   $AF
F1A4 F1 8C    2360:          FDB   SSMOD-8
F1A6 BD F194  2361: SSLASH   JSR   SSMOD
F1A9 BD E401  2362:          JSR   SWAP
F1AC BD E3F7  2363:          JSR   DROP
F1AF 39       2364:          RTS
              2365: *
F1B0 85       2366:          FCB   $85
F1B1 4D       2367:          FCC   "M/MO"
F1B2 2F 4D
F1B4 4F
F1B5 C4       2368:          FCB   $C4
F1B6 F1 A1    2369:          FDB   SSLASH-5
F1B8 BD E345  2370: MSMOD    JSR   TOR
F1BB BD E523  2371:          JSR   ZERO
F1BE BD E36A  2372:          JSR   R
F1C1 BD E29E  2373:          JSR   USLASH
F1C4 BD E358  2374:          JSR   FROMR
F1C7 BD E401  2375:          JSR   SWAP
F1CA BD E345  2376:          JSR   TOR
F1CD BD E29E  2377:          JSR   USLASH
F1D0 BD E358  2378:          JSR   FROMR
F1D3 39       2379:          RTS
              2380: *
F1D4 83       2381:          FCB   $83
F1D5 41       2382:          FCC   "AB"
F1D6 42
F1D7 D3       2383:          FCB   $D3
F1D8 F1 B0    2384:          FDB   MSMOD-8
F1DA BD E414  2385: ABS      JSR   DUP
F1DD BD E38B  2386:          JSR   ZLESS
F1E0 BD E06E  2387:          JSR   ZBRAN
F1E3 27 03    2388:          BEQ   ABS2
F1E5 BD E3C2  2389:          JSR   MINUS
F1E8 39       2390: ABS2     RTS
              2391: *
F1E9 84       2392:          FCB   $84
F1EA 44       2393:          FCC   "DAB"
F1EB 41 42
F1ED D3       2394:          FCB   $D3
F1EE F1 D4    2395:          FDB   ABS-6
F1F0 BD E414  2396: DABS     JSR   DUP
F1F3 BD E38B  2397:          JSR   ZLESS
F1F6 BD E06E  2398:          JSR   ZBRAN
F1F9 27 03    2399:          BEQ   DABS2
F1FB BD E3D2  2400:          JSR   DMINUS
F1FE 39       2401: DABS2    RTS
              2402: *
F1FF 83       2403:          FCB   $83
F200 55       2404:          FCC   "US"
F201 53
F202 C5       2405:          FCB   $C5
F203 F1 E9    2406:          FDB   DABS-7
F205 BD E4E0  2407: USE      JSR   DOCON
F208 40 40    2408:          FDB   XUSE
              2409: *
F20A 84       2410:          FCB   $84
F20B 50       2411:          FCC   "PRE"
F20C 52 45
```

```
F20E D6       2412:          FCB   $D6
F20F F1 FF    2413:          FDB   USE-6
F211 BD E4E0  2414: PREV     JSR   DOCON
F214 40 42    2415:          FDB   XPREV
              2416: *
F216 84       2417:          FCB   $84
F217 2B       2418:          FCC   "+BU"
F218 42 55
F21A C6       2419:          FCB   $C6
F21B F2 0A    2420:          FDB   PREV-7
F21D BD E044  2421: PBUF     JSR   CLITER
F220 44       2422:          FCB   $44
F221 BD E399  2423:          JSR   PLUS
F224 BD E414  2424:          JSR   DUP
F227 BD E562  2425:          JSR   LIMIT
F22A BD E712  2426:          JSR   EQUAL
F22D BD E06E  2427:          JSR   ZBRAN
F230 27 06    2428:          BEQ   PBUF2
F232 BD E3F7  2429:          JSR   DROP
F235 BD E555  2430:          JSR   FIRST
F238 BD E414  2431: PBUF2    JSR   DUP
F23B BD F211  2432:          JSR   PREV
F23E BD E44E  2433:          JSR   AT
F241 BD E707  2434:          JSR   SUB
F244 39       2435:          RTS
              2436: *
F245 86       2437:          FCB   $86
F246 55       2438:          FCC   "UPDAT"
F247 50 44
F249 41 54
F24B C5       2439:          FCB   $C5
F24C F2 16    2440:          FDB   PBUF-7
F24E BD F211  2441: UPDATE   JSR   PREV
F251 BD E44E  2442:          JSR   AT
F254 BD E44E  2443:          JSR   AT
F257 BD E02C  2444:          JSR   LIT
F25A 80 00    2445:          FDB   $8000
F25C BD E2E5  2446:          JSR   OR
F25F BD F211  2447:          JSR   PREV
F262 BD E44E  2448:          JSR   AT
F265 BD E46E  2449:          JSR   STORE
F268 39       2450:          RTS
              2451: *
F269 8D       2452:          FCB   $8D
F26A 45       2453:          FCC   "EMPTY-BUFFER"
F26B 4D 50
F26D 54 59
F26F 2D 42
F271 55 46
F273 46 45
F275 52
F276 D3       2454:          FCB   $D3
F277 F2 45    2455:          FDB   UPDATE-9
F279 BD E555  2456: MTBUF    JSR   FIRST
F27C BD E562  2457:          JSR   LIMIT
F27F BD E3E9  2458:          JSR   OVER
F282 BD E707  2459:          JSR   SUB
F285 BD EC11  2460:          JSR   ERASE
F288 39       2461:          RTS
              2462: *
```

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```
F289 83      2463:          FCB   $83
F28A 44      2464:          FCC   "DR"
F28B 52
F28C B0      2465:          FCB   $B0
F28D F2 69   2466:          FDB   MTBUF-16
F28F BD E523 2467: DRZERO   JSR   ZERO
F292 BD E62A 2468:          JSR   OFSET
F295 BD E46E 2469:          JSR   STORE
F298 39      2470:          RTS
             2471: *
F299 83      2472:          FCB   $83
F29A 44      2473:          FCC   "DR"
F29B 52
F29C B1      2474:          FCB   $B1
F29D F2 89   2475:          FDB   DRZERO-6
F29F BD E02C 2476: DRONE    JSR   LIT
F2A2 07 D0   2477:          FDB   $7D0
F2A4 BD E62A 2478:          JSR   OFSET
F2A7 BD E46E 2479:          JSR   STORE
F2AA 39      2480:          RTS
             2481: *
F2AB 86      2482:          FCB   $86
F2AC 42      2483:          FCC   "BUFFE"
F2AD 55 46
F2AF 46 45
F2B1 D2      2484:          FCB   $D2
F2B2 F2 99   2485:          FDB   DRONE-6
F2B4 BD F205 2486: BUFFER   JSR   USE
F2B7 BD E44E 2487:          JSR   AT
F2BA BD E414 2488:          JSR   DUP
F2BD BD E345 2489:          JSR   TOR
F2C0 BD F21D 2490: BUFFR2   JSR   PBUF
F2C3 BD E06E 2491:          JSR   ZBRAN
F2C6 27 F8   2492:          BEQ   BUFFR2
F2C8 BD F205 2493:          JSR   USE
F2CB BD E46E 2494:          JSR   STORE
F2CE BD E36A 2495:          JSR   R
F2D1 BD E44E 2496:          JSR   AT
F2D4 BD E38B 2497:          JSR   ZLESS
F2D7 BD E06E 2498:          JSR   ZBRAN
F2DA 27 1A   2499:          BEQ   BUFFR3
F2DC BD E36A 2500:          JSR   R
F2DF BD E6BC 2501:          JSR   TWOP
F2E2 BD E36A 2502:          JSR   R
F2E5 BD E44E 2503:          JSR   AT
F2E8 BD E02C 2504:          JSR   LIT
F2EB 7F FF   2505:          FDB   $7FFF
F2ED BD E2D5 2506:          JSR   AND
F2F0 BD E523 2507:          JSR   ZERO
F2F3 BD F4FA 2508:          JSR   RW
F2F6 BD E36A 2509: BUFFR3   JSR   R
F2F9 BD E46E 2510:          JSR   STORE
F2FC BD E36A 2511:          JSR   R
F2FF BD F211 2512:          JSR   PREV
F302 BD E46E 2513:          JSR   STORE
F305 BD E358 2514:          JSR   FROMR
F308 BD E6BC 2515:          JSR   TWOP
F30B 39      2516:          RTS
             2517: *
F30C 85      2518:          FCB   $85
```

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```
F30D 42       2519:          FCC    "BLOC"
F30E 4C 4F
F310 43
F311 CB       2520:          FCB    $CB
F312 F2 AB    2521:          FDB    BUFFER-9
F314 BD E62A  2522: BLOCK    JSR    OFSET
F317 BD E44E  2523:          JSR    AT
F31A BD E399  2524:          JSR    PLUS
F31D BD E345  2525:          JSR    TOR
F320 BD F211  2526:          JSR    PREV
F323 BD E44E  2527:          JSR    AT
F326 BD E414  2528:          JSR    DUP
F329 BD E44E  2529:          JSR    AT
F32C BD E36A  2530:          JSR    R
F32F BD E707  2531:          JSR    SUB
F332 BD E414  2532:          JSR    DUP
F335 BD E399  2533:          JSR    PLUS
F338 BD E06E  2534:          JSR    ZBRAN
F33B 27 49    2535:          BEQ    BLOCK5
F33D BD F21D  2536: BLOCK3   JSR    PBUF
F340 BD E37B  2537:          JSR    ZEQU
F343 BD E06E  2538:          JSR    ZBRAN
F346 27 1B    2539:          BEQ    BLOCK4
F348 BD E3F7  2540:          JSR    DROP
F34B BD E36A  2541:          JSR    R
F34E BD F2B4  2542:          JSR    BUFFER
F351 BD E414  2543:          JSR    DUP
F354 BD E36A  2544:          JSR    R
F357 BD E52C  2545:          JSR    ONE
F35A BD F4FA  2546:          JSR    RW
F35D BD E535  2547:          JSR    TWO
F360 BD E707  2548:          JSR    SUB
F363 BD E414  2549: BLOCK4   JSR    DUP
F366 BD E44E  2550:          JSR    AT
F369 BD E36A  2551:          JSR    R
F36C BD E707  2552:          JSR    SUB
F36F BD E414  2553:          JSR    DUP
F372 BD E399  2554:          JSR    PLUS
F375 BD E37B  2555:          JSR    ZEQU
F378 BD E06E  2556:          JSR    ZBRAN
F37B 27 C0    2557:          BEQ    BLOCK3
F37D BD E414  2558:          JSR    DUP
F380 BD F211  2559:          JSR    PREV
F383 BD E46E  2560:          JSR    STORE
F386 BD E358  2561: BLOCK5   JSR    FROMR
F389 BD E3F7  2562:          JSR    DROP
F38C BD E6BC  2563:          JSR    TWOP
F38F 39       2564:          RTS
              2565: *
F390 86       2566:          FCB    $86
F391 28       2567:          FCC    "(LINE"
F392 4C 49
F394 4E 45
F396 A9       2568:          FCB    $A9
F397 F3 0C    2569:          FDB    BLOCK-8
F399 BD E345  2570: PLINE    JSR    TOR
F39C BD E044  2571:          JSR    CLITER
F39F 40       2572:          FCB    $40
F3A0 BD E56F  2573:          JSR    BBUF
F3A3 BD F194  2574:          JSR    SSMOD
```

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```
F3A6 BD E358 2575:          JSR   FROMR
F3A9 BD E57C 2576:          JSR   BSCR
F3AC BD F157 2577:          JSR   STAR
F3AF BD E399 2578:          JSR   PLUS
F3B2 BD F314 2579:          JSR   BLOCK
F3B5 BD E399 2580:          JSR   PLUS
F3B8 BD E044 2581:          JSR   CLITER
F3BB 40      2582:          FCB   $40
F3BC 39      2583:          RTS
             2584: *
F3BD 85      2585:          FCB   $85
F3BE 2E      2586:          FCC   ".LIN"
F3BF 4C 49
F3C1 4E
F3C2 C5      2587:          FCB   $C5
F3C3 F3 90   2588:          FDB   PLINE-9
F3C5 BD F399 2589: DLINE    JSR   PLINE
F3C8 BD EA26 2590:          JSR   DTRAIL
F3CB BD E9EB 2591:          JSR   TYPE
F3CE 39      2592:          RTS
             2593: *
F3CF 87      2594:          FCB   $87
F3D0 4D      2595:          FCC   "MESSAG"
F3D1 45 53
F3D3 53 41
F3D5 47
F3D6 C5      2596:          FCB   $C5
F3D7 F3 BD   2597:          FDB   DLINE-8
F3D9 BD E5CA 2598: MESS     JSR   WARN
F3DC BD E44E 2599:          JSR   AT
F3DF BD E06E 2600:          JSR   ZBRAN
F3E2 27 20   2601:          BEQ   MESS3
F3E4 BD E79E 2602:          JSR   DDUP
F3E7 BD E06E 2603:          JSR   ZBRAN
F3EA 27 25   2604:          BEQ   MESS4
F3EC BD E044 2605:          JSR   CLITER
F3EF 04      2606:          FCB   4
F3F0 BD E62A 2607:          JSR   OFSET
F3F3 BD E44E 2608:          JSR   AT
F3F6 BD E57C 2609:          JSR   BSCR
F3F9 BD F175 2610:          JSR   SLASH
F3FC BD E707 2611:          JSR   SUB
F3FF BD F3C5 2612:          JSR   DLINE
F402 20 0D   2613: MESS2    BRA   MESS4
F404 BD EA64 2614: MESS3    JSR   PDOTQ
F407 06      2615:          FCB   6
F408 65      2616:          FCC   "err # "
F409 72 72
F40B 20 23
F40D 20
F40E BD F814 2617:          JSR   DOT
F411 39      2618: MESS4    RTS
             2619: *
F412 84      2620:          FCB   $84
F413 4C      2621:          FCC   "LOA"
F414 4F 41
F416 C4      2622:          FCB   $C4
F417 F3 CF   2623:          FDB   MESS-10
F419 BD E5FC 2624: LOAD     JSR   BLK
F41C BD E44E 2625:          JSR   AT
```

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```
F41F BD E345 2626:          JSR   TOR
F422 BD E606 2627:          JSR   IN
F425 BD E44E 2628:          JSR   AT
F428 BD E345 2629:          JSR   TOR
F42B BD E523 2630:          JSR   ZERO
F42E BD E606 2631:          JSR   IN
F431 BD E46E 2632:          JSR   STORE
F434 BD E57C 2633:          JSR   BSCR
F437 BD F157 2634:          JSR   STAR
F43A BD E5FC 2635:          JSR   BLK
F43D BD E46E 2636:          JSR   STORE
F440 BD EF33 2637:          JSR   INTERP
F443 BD E358 2638:          JSR   FROMR
F446 BD E606 2639:          JSR   IN
F449 BD E46E 2640:          JSR   STORE
F44C BD E358 2641:          JSR   FROMR
F44F BD E5FC 2642:          JSR   BLK
F452 BD E46E 2643:          JSR   STORE
F455 39      2644:          RTS
             2645: *
F456 C3      2646:          FCB   $C3
F457 2D      2647:          FCC   "--"
F458 2D
F459 BE      2648:          FCB   $BE
F45A F4 12   2649:          FDB   LOAD-7
F45C BD E8B4 2650: ARROW    JSR   QLOAD
F45F BD E523 2651:          JSR   ZERO
F462 BD E606 2652:          JSR   IN
F465 BD E46E 2653:          JSR   STORE
F468 BD E57C 2654:          JSR   BSCR
F46B BD E5FC 2655:          JSR   BLK
F46E BD E44E 2656:          JSR   AT
F471 BD E3E9 2657:          JSR   OVER
F474 BD F185 2658:          JSR   MOD
F477 BD E707 2659:          JSR   SUB
F47A BD E5FC 2660:          JSR   BLK
F47D BD E420 2661:          JSR   PSTORE
F480 39      2662:          RTS
             2663: *
F481 D7 E0   2664: PEMIT    STA B N
F483 DF E1   2665:          STX   N+1
F485 7D 0002 2666: PEMIT2   TST   $2
F488 2B FB   2667:          BMI   PEMIT2
F48A D6 11   2668: PEMIT3   LDA B ACIAC
F48C C5 20   2669:          BIT B #$20
F48E 27 FA   2670:          BEQ   PEMIT3
F490 97 13   2671:          STA A ACIAD+1
F492 DE F2   2672:          LDX   UP
F494 E7 36   2673:          STA B IOSTAT-UORIG,X
F496 D6 E0   2674:          LDA B N
F498 DE E1   2675:          LDX   N+1
F49A 39      2676:          RTS
             2677: *
F49B D7 E0   2678: PKEY     STA B N
F49D DF E1   2679:          STX   N+1
F49F D6 11   2680:          LDA B ACIAC
F4A1 59      2681:          ROL B
F4A2 24 FB   2682:          BCC   PKEY+4
F4A4 96 12   2683:          LDA A ACIAD
F4A6 84 7F   2684:          AND A #$7F
```

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```
F4A8 DE F2    2685:          LDX    UP
F4AA E7 37    2686:          STA B  IOSTAT+1-UORIG,X
F4AC D6 E0    2687:          LDA B  N
F4AE DE E1    2688:          LDX    N+1
F4B0 39       2689:          RTS
              2690: *
F4B1 96 11    2691: PQTER    LDA A  ACIAC
F4B3 84 80    2692:          AND A  #$80
F4B5 27 04    2693:          BEQ    PQTER2
F4B7 96 12    2694:          LDA A  ACIAD
F4B9 86 01    2695:          LDA A  #1
F4BB 39       2696: PQTER2   RTS
              2697: *
F4BC 86 0D    2698: PCR      LDA A  #$D
F4BE 8D C1    2699:          BSR    PEMIT
F4C0 86 0A    2700:          LDA A  #$A
F4C2 8D BD    2701:          BSR    PEMIT
F4C4 86 00    2702:          LDA A  #0
F4C6 DE F2    2703:          LDX    UP
F4C8 E6 33    2704:          LDA B  XDELAY+1-UORIG,X
F4CA 5A       2705: PCR2     DEC B
F4CB 2B EE    2706:          BMI    PQTER2
F4CD 37       2707:          PSH B
F4CE 8D B1    2708:          BSR    PEMIT
F4D0 33       2709:          PUL B
F4D1 20 F7    2710:          BRA    PCR2
              2711: *
F4D3 83       2712:          FCB    $83
F4D4 44       2713:          FCC    "DR"
F4D5 52
F4D6 C2       2714:          FCB    $C2
F4D7 F4 56    2715:          FDB    ARROW-6
F4D9 BD E4E0  2716: DRB      JSR    DOCON
F4DC 00 E0    2717:          FDB    $00E0
              2718: *
F4DE 85       2719:          FCB    $85
F4DF 44       2720:          FCC    "DRIV"
F4E0 52 49
F4E2 56
F4E3 C5       2721:          FCB    $C5
F4E4 F4 D3    2722:          FDB    DRB-6
F4E6 EC 02    2723: DRIVE    FDB    $EC02          LDD 2,X
F4E8 3C       2724:          FCB    $3C            PSHX
F4E9 FE F4DC  2725:          LDX    DRB+3
F4EC BD FDD8  2726:          JSR    BUBBLE
F4EF 38       2727:          FCB    $38            PULX
F4F0 4F       2728:          CLR A
F4F1 ED 02    2729:          FDB    $ED02          STD 2,X
F4F3 39       2730:          RTS
              2731: *
F4F4 83       2732:          FCB    $83
F4F5 52       2733:          FCC    "R/"
F4F6 2F
F4F7 D7       2734:          FCB    $D7
F4F8 F4 DE    2735:          FDB    DRIVE-8
F4FA BD E745  2736: RW       JSR    ROT
F4FD BD F4D9  2737:          JSR    DRB
F500 BD E6BC  2738:          JSR    TWOP
F503 BD E46E  2739:          JSR    STORE
F506 BD E401  2740:          JSR    SWAP
```

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```
F509 BD F4D9 2741:          JSR   DRB
F50C BD E46E 2742:          JSR   STORE
F50F BD E06E 2743:          JSR   ZBRAN
F512 27 05   2744:          BEQ   RW2
F514 BD E52C 2745:          JSR   ONE
F517 20 03   2746:          BRA   RW3
F519 BD E535 2747: RW2      JSR   TWO
F51C BD F4E6 2748: RW3      JSR   DRIVE
F51F BD E79E 2749:          JSR   DDUP
F522 BD E06E 2750:          JSR   ZBRAN
F525 27 19   2751:          BEQ   RW4
F527 BD EA64 2752:          JSR   PDOTQ
F52A 0F      2753:          FCB   15
F52B 42      2754:          FCC   "BUBBLE ERROR # "
F52C 55 42
F52E 42 4C
F530 45 20
F532 45 52
F534 52 4F
F536 52 20
F538 23 20
F53A BD F814 2755:          JSR   DOT
F53D BD F00A 2756:          JSR   QUIT
F540 39      2757: RW4      RTS
             2758: *
F541 C1      2759:          FCB   $C1
F542 A7      2760:          FCB   $A7
F543 F4 F4   2761:          FDB   RW-6
F545 BD ED95 2762: TICK     JSR   DFIND
F548 BD E37B 2763:          JSR   ZEQU
F54B BD E523 2764:          JSR   ZERO
F54E BD E83A 2765:          JSR   QERR
F551 BD E3F7 2766:          JSR   DROP
F554 BD EEF2 2767:          JSR   LITER
F557 39      2768:          RTS
             2769: *
F558 86      2770:          FCB   $86
F559 46      2771:          FCC   "FORGE"
F55A 4F 52
F55C 47 45
F55E D4      2772:          FCB   $D4
F55F F5 41   2773:          FDB   TICK-4
F561 BD E648 2774: FORGET   JSR   CURENT
F564 BD E44E 2775:          JSR   AT
F567 BD E639 2776:          JSR   CONTXT
F56A BD E44E 2777:          JSR   AT
F56D BD E707 2778:          JSR   SUB
F570 BD E044 2779:          JSR   CLITER
F573 18      2780:          FCB   $18
F574 BD E83A 2781:          JSR   QERR
F577 BD F545 2782:          JSR   TICK
F57A BD E414 2783:          JSR   DUP
F57D BD E5D7 2784:          JSR   FENCE
F580 BD E44E 2785:          JSR   AT
F583 BD E71D 2786:          JSR   LESS
F586 BD E044 2787:          JSR   CLITER
F589 15      2788:          FCB   $15
F58A BD E83A 2789:          JSR   QERR
F58D BD E414 2790:          JSR   DUP
F590 BD E523 2791:          JSR   ZERO
```

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```
F593 BD E58B 2792:          JSR   PORIG
F596 BD E71D 2793:          JSR   LESS
F599 BD E044 2794:          JSR   CLITER
F59C 15      2795:          FCB   $15
F59D BD E83A 2796:          JSR   QERR
F5A0 BD E414 2797:          JSR   DUP
F5A3 BD E7FD 2798:          JSR   NFA
F5A6 BD E5E1 2799:          JSR   DP
F5A9 BD E46E 2800:          JSR   STORE
F5AC BD E7F0 2801:          JSR   LFA
F5AF BD E44E 2802:          JSR   AT
F5B2 BD E639 2803:          JSR   CONTXT
F5B5 BD E44E 2804:          JSR   AT
F5B8 BD E46E 2805:          JSR   STORE
F5BB 39      2806:          RTS
             2807: *
F5BC 84      2808:          FCB   $84
F5BD 42      2809:          FCC   "BAC"
F5BE 41 43
F5C0 CB      2810:          FCB   $CB
F5C1 F5 58   2811:          FDB   FORGET-9
F5C3 BD E02C 2812: BACK     JSR   LIT
F5C6 26 03   2813:          FDB   $2603
F5C8 BD E6E4 2814:          JSR   COMMA
F5CB BD E044 2815:          JSR   CLITER
F5CE 7E      2816:          FCB   $7E
F5CF BD E6F6 2817:          JSR   CCOMM
F5D2 BD E6E4 2818:          JSR   COMMA
F5D5 39      2819:          RTS
             2820: *
F5D6 C5      2821:          FCB   $C5
F5D7 42      2822:          FCC   "BEGI"
F5D8 45 47
F5DA 49
F5DB CE      2823:          FCB   $CE
F5DC F5 BC   2824:          FDB   BACK-7
F5DE BD E853 2825: BEGIN    JSR   QCOMP
F5E1 BD E6CA 2826:          JSR   HERE
F5E4 BD E52C 2827:          JSR   ONE
F5E7 39      2828:          RTS
             2829: *
F5E8 C5      2830:          FCB   $C5
F5E9 45      2831:          FCC   "ENDI"
F5EA 4E 44
F5EC 49
F5ED C6      2832:          FCB   $C6
F5EE F5 D6   2833:          FDB   BEGIN-8
F5F0 BD E853 2834: ENDIF    JSR   QCOMP
F5F3 BD E535 2835:          JSR   TWO
F5F6 BD E883 2836:          JSR   QPAIRS
F5F9 BD E6CA 2837:          JSR   HERE
F5FC BD E401 2838:          JSR   SWAP
F5FF BD E46E 2839:          JSR   STORE
F602 39      2840:          RTS
             2841: *
F603 C4      2842:          FCB   $C4
F604 54      2843:          FCC   "THE"
F605 48 45
F607 CE      2844:          FCB   $CE
F608 F5 E8   2845:          FDB   ENDIF-8
```

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```
F60A BD F5F0 2846: THEN   JSR   ENDIF
F60D 39      2847:        RTS
             2848: *
F60E C2      2849:        FCB   $C2
F60F 44      2850:        FCC   "D"
F610 CF      2851:        FCB   $CF
F611 F6 03   2852:        FDB   THEN-7
F613 BD E8CF 2853: DO     JSR   COMPIL
F616 BD E0C1 2854:        JSR   XDO
F619 BD E6CA 2855:        JSR   HERE
F61C BD E53E 2856:        JSR   THREE
F61F 39      2857:        RTS
             2858: *
F620 C4      2859:        FCB   $C4
F621 4C      2860:        FCC   "LOO"
F622 4F 4F
F624 D0      2861:        FCB   $D0
F625 F6 0E   2862:        FDB   DO-5
F627 BD E53E 2863: LOOP   JSR   THREE
F62A BD E883 2864:        JSR   QPAIRS
F62D BD E8CF 2865:        JSR   COMPIL
F630 BD E07C 2866:        JSR   XLOOP
F633 BD F5C3 2867:        JSR   BACK
F636 39      2868:        RTS
             2869: *
F637 C5      2870:        FCB   $C5
F638 2B      2871:        FCC   "+LOO"
F639 4C 4F
F63B 4F
F63C D0      2872:        FCB   $D0
F63D F6 20   2873:        FDB   LOOP-7
F63F BD E53E 2874: PLOOP  JSR   THREE
F642 BD E883 2875:        JSR   QPAIRS
F645 BD E8CF 2876:        JSR   COMPIL
F648 BD E08B 2877:        JSR   XPLOOP
F64B BD F5C3 2878:        JSR   BACK
F64E 39      2879:        RTS
             2880: *
F64F C5      2881:        FCB   $C5
F650 55      2882:        FCC   "UNTI"
F651 4E 54
F653 49
F654 CC      2883:        FCB   $CC
F655 F6 37   2884:        FDB   PLOOP-8
F657 BD E52C 2885: UNTIL  JSR   ONE
F65A BD E883 2886:        JSR   QPAIRS
F65D BD E8CF 2887:        JSR   COMPIL
F660 BD E06E 2888:        JSR   ZBRAN
F663 BD F5C3 2889:        JSR   BACK
F666 39      2890:        RTS
             2891: *
F667 C3      2892:        FCB   $C3
F668 45      2893:        FCC   "EN"
F669 4E
F66A C4      2894:        FCB   $C4
F66B F6 4F   2895:        FDB   UNTIL-8
F66D BD F657 2896: END    JSR   UNTIL
F670 39      2897:        RTS
             2898: *
F671 C5      2899:        FCB   $C5
```

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```
F672 41       2900:          FCC   "AGAI"
F673 47 41
F675 49
F676 CE       2901:          FCB   $CE
F677 F6 67    2902:          FDB   END-6
F679 BD E52C  2903: AGAIN    JSR   ONE
F67C BD E883  2904:          JSR   QPAIRS
F67F BD E044  2905:          JSR   CLITER
F682 7E       2906:          FCB   $7E
F683 BD E6F6  2907:          JSR   CCOMM
F686 BD E6E4  2908:          JSR   COMMA
F689 39       2909:          RTS
              2910: *
F68A C6       2911:          FCB   $C6
F68B 52       2912:          FCC   "REPEA"
F68C 45 50
F68E 45 41
F690 D4       2913:          FCB   $D4
F691 F6 71    2914:          FDB   AGAIN-8
F693 BD E345  2915: REPEAT   JSR   TOR
F696 BD E345  2916:          JSR   TOR
F699 BD F679  2917:          JSR   AGAIN
F69C BD E358  2918:          JSR   FROMR
F69F BD E358  2919:          JSR   FROMR
F6A2 BD E535  2920:          JSR   TWO
F6A5 BD E707  2921:          JSR   SUB
F6A8 BD F5F0  2922:          JSR   ENDIF
F6AB 39       2923:          RTS
              2924: *
F6AC C2       2925:          FCB   $C2
F6AD 49       2926:          FCC   "I"
F6AE C6       2927:          FCB   $C6
F6AF F6 8A    2928:          FDB   REPEAT-9
F6B1 BD E8CF  2929: IF       JSR   COMPIL
F6B4 BD E06E  2930:          JSR   ZBRAN
F6B7 BD E02C  2931:          JSR   LIT
F6BA 26 03    2932:          FDB   $2603
F6BC BD E6E4  2933:          JSR   COMMA
F6BF BD E044  2934:          JSR   CLITER
F6C2 7E       2935:          FCB   $7E
F6C3 BD E6F6  2936:          JSR   CCOMM
F6C6 BD E6CA  2937:          JSR   HERE
F6C9 BD E523  2938:          JSR   ZERO
F6CC BD E6E4  2939:          JSR   COMMA
F6CF BD E535  2940:          JSR   TWO
F6D2 39       2941:          RTS
              2942: *
F6D3 C4       2943:          FCB   $C4
F6D4 45       2944:          FCC   "ELS"
F6D5 4C 53
F6D7 C5       2945:          FCB   $C5
F6D8 F6 AC    2946:          FDB   IF-5
F6DA BD E535  2947: ELSE     JSR   TWO
F6DD BD E883  2948:          JSR   QPAIRS
F6E0 BD E044  2949:          JSR   CLITER
F6E3 7E       2950:          FCB   $7E
F6E4 BD E6F6  2951:          JSR   CCOMM
F6E7 BD E6CA  2952:          JSR   HERE
F6EA BD E523  2953:          JSR   ZERO
F6ED BD E6E4  2954:          JSR   COMMA
```

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```
F6F0 BD E401 2955:          JSR   SWAP
F6F3 BD E535 2956:          JSR   TWO
F6F6 BD F5F0 2957:          JSR   ENDIF
F6F9 BD E535 2958:          JSR   TWO
F6FC 39      2959:          RTS
             2960: *
F6FD C5      2961:          FCB   $C5
F6FE 57      2962:          FCC   "WHIL"
F6FF 48 49
F701 4C
F702 C5      2963:          FCB   $C5
F703 F6 D3   2964:          FDB   ELSE-7
F705 BD F6B1 2965: WHILE    JSR   IF
F708 BD E6BC 2966:          JSR   TWOP
F70B 39      2967:          RTS
             2968: *
F70C 86      2969:          FCB   $86
F70D 53      2970:          FCC   "SPACE"
F70E 50 41
F710 43 45
F712 D3      2971:          FCB   $D3
F713 F6 FD   2972:          FDB   WHILE-8
F715 BD E523 2973: SPACES   JSR   ZERO
F718 BD E782 2974:          JSR   MAX
F71B BD E79E 2975:          JSR   DDUP
F71E BD E06E 2976:          JSR   ZBRAN
F721 27 0E   2977:          BEQ   SPACE3
F723 BD E523 2978:          JSR   ZERO
F726 BD E0C1 2979:          JSR   XDO
F729 BD E75A 2980: SPACE2   JSR   SPACE
F72C BD E07C 2981:          JSR   XLOOP
F72F 27 F8   2982:          BEQ   SPACE2
F731 39      2983: SPACE3   RTS
             2984: *
F732 82      2985:          FCB   $82
F733 3C      2986:          FCC   "<"
F734 A3      2987:          FCB   $A3
F735 F7 0C   2988:          FDB   SPACES-9
F737 BD EC4A 2989: BDIGS    JSR   PAD
F73A BD E697 2990:          JSR   HLD
F73D BD E46E 2991:          JSR   STORE
F740 39      2992:          RTS
             2993: *
F741 82      2994:          FCB   $82
F742 23      2995:          FCC   "#"
F743 BE      2996:          FCB   $BE
F744 F7 32   2997:          FDB   BDIGS-5
F746 BD E3F7 2998: EDIGS    JSR   DROP
F749 BD E3F7 2999:          JSR   DROP
F74C BD E697 3000:          JSR   HLD
F74F BD E44E 3001:          JSR   AT
F752 BD EC4A 3002:          JSR   PAD
F755 BD E3E9 3003:          JSR   OVER
F758 BD E707 3004:          JSR   SUB
F75B 39      3005:          RTS
             3006: *
F75C 84      3007:          FCB   $84
F75D 53      3008:          FCC   "SIG"
F75E 49 47
F760 CE      3009:          FCB   $CE
```

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```
F761 F7 41    3010:          FDB   EDIGS-5
F763 BD E745  3011: SIGN     JSR   ROT
F766 BD E38B  3012:          JSR   ZLESS
F769 BD E06E  3013:          JSR   ZBRAN
F76C 27 07    3014:          BEQ   SIGN2
F76E BD E044  3015:          JSR   CLITER
F771 2D       3016:          FCC   "-"
F772 BD EC2F  3017:          JSR   HOLD
F775 39       3018: SIGN2    RTS
              3019: *
F776 81       3020:          FCB   $81
F777 A3       3021:          FCB   $A3
F778 F7 5C    3022:          FDB   SIGN-7
F77A BD E661  3023: DIG      JSR   BASE
F77D BD E44E  3024:          JSR   AT
F780 BD F1B8  3025:          JSR   MSMOD
F783 BD E745  3026:          JSR   ROT
F786 BD E044  3027:          JSR   CLITER
F789 09       3028:          FCB   9
F78A BD E3E9  3029:          JSR   OVER
F78D BD E71D  3030:          JSR   LESS
F790 BD E06E  3031:          JSR   ZBRAN
F793 27 07    3032:          BEQ   DIG2
F795 BD E044  3033:          JSR   CLITER
F798 07       3034:          FCB   7
F799 BD E399  3035:          JSR   PLUS
F79C BD E044  3036: DIG2     JSR   CLITER
F79F 30       3037:          FCC   "0"
F7A0 BD E399  3038:          JSR   PLUS
F7A3 BD EC2F  3039:          JSR   HOLD
F7A6 39       3040:          RTS
              3041: *
F7A7 82       3042:          FCB   $82
F7A8 23       3043:          FCC   "#"
F7A9 D3       3044:          FCB   $D3
F7AA F7 76    3045:          FDB   DIG-4
F7AC BD F77A  3046: DIGS     JSR   DIG
F7AF BD E3E9  3047:          JSR   OVER
F7B2 BD E3E9  3048:          JSR   OVER
F7B5 BD E2E5  3049:          JSR   OR
F7B8 BD E37B  3050:          JSR   ZEQU
F7BB BD E06E  3051:          JSR   ZBRAN
F7BE 27 EC    3052:          BEQ   DIGS
F7C0 39       3053:          RTS
              3054: *
F7C1 82       3055:          FCB   $82
F7C2 2E       3056:          FCC   "."
F7C3 D2       3057:          FCB   $D2
F7C4 F7 A7    3058:          FDB   DIGS-5
F7C6 BD E345  3059: DOTR     JSR   TOR
F7C9 BD F149  3060:          JSR   STOD
F7CC BD E358  3061:          JSR   FROMR
F7CF BD F7D9  3062:          JSR   DDOTR
F7D2 39       3063:          RTS
              3064: *
F7D3 83       3065:          FCB   $83
F7D4 44       3066:          FCC   "D."
F7D5 2E
F7D6 D2       3067:          FCB   $D2
F7D7 F7 C1    3068:          FDB   DOTR-5
```

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```
F7D9 BD E345 3069: DDOTR  JSR   TOR
F7DC BD E401 3070:        JSR   SWAP
F7DF BD E3E9 3071:        JSR   OVER
F7E2 BD F1F0 3072:        JSR   DABS
F7E5 BD F737 3073:        JSR   BDIGS
F7E8 BD F7AC 3074:        JSR   DIGS
F7EB BD F763 3075:        JSR   SIGN
F7EE BD F746 3076:        JSR   EDIGS
F7F1 BD E358 3077:        JSR   FROMR
F7F4 BD E3E9 3078:        JSR   OVER
F7F7 BD E707 3079:        JSR   SUB
F7FA BD F715 3080:        JSR   SPACES
F7FD BD E9EB 3081:        JSR   TYPE
F800 39      3082:        RTS
             3083: *
F801 82      3084:        FCB   $82
F802 44      3085:        FCC   "D"
F803 AE      3086:        FCB   $AE
F804 F7 D3   3087:        FDB   DDOTR-6
F806 BD E523 3088: DDOT   JSR   ZERO
F809 BD F7D9 3089:        JSR   DDOTR
F80C BD E75A 3090:        JSR   SPACE
F80F 39      3091:        RTS
             3092: *
F810 81      3093:        FCB   $81
F811 AE      3094:        FCB   $AE
F812 F8 01   3095:        FDB   DDOT-5
F814 BD F149 3096: DOT    JSR   STOD
F817 BD F806 3097:        JSR   DDOT
F81A 39      3098:        RTS
             3099: *
F81B 81      3100:        FCB   $81
F81C BF      3101:        FCB   $BF
F81D F8 10   3102:        FDB   DOT-4
F81F BD E44E 3103: QUEST  JSR   AT
F822 BD F814 3104:        JSR   DOT
F825 39      3105:        RTS
             3106: *
F826 84      3107:        FCB   $84
F827 4C      3108:        FCC   "LIS"
F828 49 53
F82A D4      3109:        FCB   $D4
F82B F8 1B   3110:        FDB   QUEST-4
F82D BD E93D 3111: LIST   JSR   DEC
F830 BD E21D 3112:        JSR   CR
F833 BD E414 3113:        JSR   DUP
F836 BD E61C 3114:        JSR   SCR
F839 BD E46E 3115:        JSR   STORE
F83C BD EA64 3116:        JSR   PDOTQ
F83F 06      3117:        FCB   6
F840 53      3118:        FCC   "SCR # "
F841 43 52
F843 20 23
F845 20
F846 BD F814 3119:        JSR   DOT
F849 BD E044 3120:        JSR   CLITER
F84C 10      3121:        FCB   $10
F84D BD E523 3122:        JSR   ZERO
F850 BD E0C1 3123:        JSR   XDO
F853 BD E21D 3124: LIST2  JSR   CR
```

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```
F856 BD E0DA 3125:          JSR   I
F859 BD E53E 3126:          JSR   THREE
F85C BD F7C6 3127:          JSR   DOTR
F85F BD E75A 3128:          JSR   SPACE
F862 BD E0DA 3129:          JSR   I
F865 BD E61C 3130:          JSR   SCR
F868 BD E44E 3131:          JSR   AT
F86B BD F3C5 3132:          JSR   DLINE
F86E BD E07C 3133:          JSR   XLOOP
F871 27 E0   3134:          BEQ   LIST2
F873 BD E21D 3135:          JSR   CR
F876 39      3136:          RTS
             3137: *
F877 85      3138:          FCB   $85
F878 49      3139:          FCC   "INDE"
F879 4E 44
F87B 45
F87C D8      3140:          FCB   $D8
F87D F8 26   3141:          FDB   LIST-7
F87F BD E21D 3142: INDEX    JSR   CR
F882 BD E6B0 3143:          JSR   ONEP
F885 BD E401 3144:          JSR   SWAP
F888 BD E0C1 3145:          JSR   XDO
F88B BD E21D 3146: INDEX2   JSR   CR
F88E BD E0DA 3147:          JSR   I
F891 BD E53E 3148:          JSR   THREE
F894 BD F7C6 3149:          JSR   DOTR
F897 BD E75A 3150:          JSR   SPACE
F89A BD E523 3151:          JSR   ZERO
F89D BD E0DA 3152:          JSR   I
F8A0 BD F3C5 3153:          JSR   DLINE
F8A3 BD E211 3154:          JSR   QTERM
F8A6 BD E06E 3155:          JSR   ZBRAN
F8A9 27 03   3156:          BEQ   INDEX3
F8AB BD E336 3157:          JSR   LEAVE
F8AE BD E07C 3158: INDEX3   JSR   XLOOP
F8B1 27 D8   3159:          BEQ   INDEX2
F8B3 BD E21D 3160:          JSR   CR
F8B6 39      3161:          RTS
             3162: *
F8B7 85      3163:          FCB   $85
F8B8 54      3164:          FCC   "TRIA"
F8B9 52 49
F8BB 41
F8BC C4      3165:          FCB   $C4
F8BD F8 77   3166:          FDB   INDEX-8
F8BF BD E53E 3167: TRIAD    JSR   THREE
F8C2 BD F175 3168:          JSR   SLASH
F8C5 BD E53E 3169:          JSR   THREE
F8C8 BD F157 3170:          JSR   STAR
F8CB BD E53E 3171:          JSR   THREE
F8CE BD E3E9 3172:          JSR   OVER
F8D1 BD E399 3173:          JSR   PLUS
F8D4 BD E401 3174:          JSR   SWAP
F8D7 BD E0C1 3175:          JSR   XDO
F8DA BD E21D 3176: TRIAD2   JSR   CR
F8DD BD E0DA 3177:          JSR   I
F8E0 BD F82D 3178:          JSR   LIST
F8E3 BD E211 3179:          JSR   QTERM
F8E6 BD E06E 3180:          JSR   ZBRAN
```

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```
F8E9 27 03    3181:          BEQ    TRIAD3
F8EB BD E336  3182:          JSR    LEAVE
F8EE BD E07C  3183: TRIAD3   JSR    XLOOP
F8F1 27 E7    3184:          BEQ    TRIAD2
F8F3 BD E21D  3185:          JSR    CR
F8F6 BD E044  3186:          JSR    CLITER
F8F9 0F       3187:          FCB    $0F
F8FA BD F3D9  3188:          JSR    MESS
F8FD BD E21D  3189:          JSR    CR
F900 39       3190:          RTS
              3191: *
F901 85       3192:          FCB    $85
F902 56       3193:          FCC    "VLIS"
F903 4C 49
F905 53
F906 D4       3194:          FCB    $D4
F907 F8 B7    3195:          FDB    TRIAD-8
F909 BD E044  3196: VLIST    JSR    CLITER
F90C 80       3197:          FCB    $80
F90D BD E611  3198:          JSR    OUT
F910 BD E46E  3199:          JSR    STORE
F913 BD E639  3200:          JSR    CONTXT
F916 BD E44E  3201:          JSR    AT
F919 BD E44E  3202:          JSR    AT
F91C BD E611  3203: VLIST1   JSR    OUT
F91F BD E44E  3204:          JSR    AT
F922 BD E6A6  3205:          JSR    COLUMS
F925 BD E44E  3206:          JSR    AT
F928 BD E044  3207:          JSR    CLITER
F92B 20       3208:          FCB    32
F92C BD E707  3209:          JSR    SUB
F92F BD E738  3210:          JSR    GREAT
F932 BD E06E  3211:          JSR    ZBRAN
F935 27 0C    3212:          BEQ    VLIST2
F937 BD E21D  3213:          JSR    CR
F93A BD E523  3214:          JSR    ZERO
F93D BD E611  3215:          JSR    OUT
F940 BD E46E  3216:          JSR    STORE
F943 BD E414  3217: VLIST2   JSR    DUP
F946 BD EE16  3218:          JSR    IDDOT
F949 BD E75A  3219:          JSR    SPACE
F94C BD E75A  3220:          JSR    SPACE
F94F BD E813  3221:          JSR    PFA
F952 BD E7F0  3222:          JSR    LFA
F955 BD E44E  3223:          JSR    AT
F958 BD E414  3224:          JSR    DUP
F95B BD E37B  3225:          JSR    ZEQU
F95E BD E211  3226:          JSR    QTERM
F961 BD E2E5  3227:          JSR    OR
F964 BD E06E  3228:          JSR    ZBRAN
F967 27 B3    3229:          BEQ    VLIST1
F969 BD E3F7  3230:          JSR    DROP
F96C BD E21D  3231:          JSR    CR
F96F 39       3232:          RTS
              3233: *
F970 83       3234:          FCB    $83
F971 44       3235:          FCC    "D+"
F972 2B
F973 AD       3236:          FCB    $AD
F974 F9 01    3237:          FDB    VLIST-8
```

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```
F976 BD E38B 3238: DPLMI   JSR    ZLESS
F979 BD E06E 3239:         JSR    ZBRAN
F97C 27 03   3240:         BEQ    DPLMI2
F97E BD E3D2 3241:         JSR    DMINUS
F981 39      3242: DPLMI2  RTS
             3243: *
F982 82      3244:         FCB    $82
F983 2B      3245:         FCC    "+"
F984 AD      3246:         FCB    $AD
F985 F9 70   3247:         FDB    DPLMI-6
F987 BD E38B 3248: PLMI    JSR    ZLESS
F98A BD E06E 3249:         JSR    ZBRAN
F98D 27 03   3250:         BEQ    PLMI2
F98F BD E3C2 3251:         JSR    MINUS
F992 39      3252: PLMI2   RTS
             3253: *
F993 82      3254:         FCB    $82
F994 4D      3255:         FCC    "M"
F995 AA      3256:         FCB    $AA
F996 F9 82   3257:         FDB    PLMI-5
F998 BD E3E9 3258: MSTAR   JSR    OVER
F99B BD E3E9 3259:         JSR    OVER
F99E BD E2F6 3260:         JSR    XOR
F9A1 BD E345 3261:         JSR    TOR
F9A4 BD F1DA 3262:         JSR    ABS
F9A7 BD E401 3263:         JSR    SWAP
F9AA BD F1DA 3264:         JSR    ABS
F9AD BD E262 3265:         JSR    USTAR
F9B0 BD E358 3266:         JSR    FROMR
F9B3 BD F976 3267:         JSR    DPLMI
F9B6 39      3268:         RTS
             3269: *
F9B7 82      3270:         FCB    $82
F9B8 4D      3271:         FCC    "M"
F9B9 AF      3272:         FCB    $AF
F9BA F9 93   3273:         FDB    MSTAR-5
F9BC BD E3E9 3274: MSLASH  JSR    OVER
F9BF BD E345 3275:         JSR    TOR
F9C2 BD E345 3276:         JSR    TOR
F9C5 BD F1F0 3277:         JSR    DABS
F9C8 BD E36A 3278:         JSR    R
F9CB BD F1DA 3279:         JSR    ABS
F9CE BD E29E 3280:         JSR    USLASH
F9D1 BD E358 3281:         JSR    FROMR
F9D4 BD E36A 3282:         JSR    R
F9D7 BD E2F6 3283:         JSR    XOR
F9DA BD F987 3284:         JSR    PLMI
F9DD BD E401 3285:         JSR    SWAP
F9E0 BD E358 3286:         JSR    FROMR
F9E3 BD F987 3287:         JSR    PLMI
F9E6 BD E401 3288:         JSR    SWAP
F9E9 39      3289:         RTS
             3290: *
F9EA 83      3291:         FCB    $83
F9EB 43      3292:         FCC    "C/"
F9EC 2F
F9ED CC      3293:         FCB    $CC
F9EE F9 B7   3294:         FDB    MSLASH-5
F9F0 BD E4E0 3295: CL      JSR    DOCON
F9F3 00 40   3296:         FDB    $40
```

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```
                    3297: *
F9F5 84             3298:          FCB   $84
F9F6 54             3299:          FCC   "TEX"
F9F7 45 58
F9F9 D4             3300:          FCB   $D4
F9FA F9 EA          3301:          FDB   CL-6
F9FC BD E6CA        3302: TEXT     JSR   HERE
F9FF BD F9F0        3303:          JSR   CL
FA02 BD E6B0        3304:          JSR   ONEP
FA05 BD EC21        3305:          JSR   BLANKS
FA08 BD EC5C        3306:          JSR   WORD
FA0B BD E6CA        3307:          JSR   HERE
FA0E BD EC4A        3308:          JSR   PAD
FA11 BD F9F0        3309:          JSR   CL
FA14 BD E6B0        3310:          JSR   ONEP
FA17 BD E22D        3311:          JSR   CMOVE
FA1A 39             3312:          RTS
                    3313: *
FA1B 84             3314:          FCB   $84
FA1C 4C             3315:          FCC   "LIN"
FA1D 49 4E
FA1F C5             3316:          FCB   $C5
FA20 F9 F5          3317:          FDB   TEXT-7
FA22 BD E414        3318: LINE     JSR   DUP
FA25 BD E02C        3319:          JSR   LIT
FA28 FF F0          3320:          FDB   $FFF0
FA2A BD E2D5        3321:          JSR   AND
FA2D BD E044        3322:          JSR   CLITER
FA30 17             3323:          FCB   $17
FA31 BD E83A        3324:          JSR   QERR
FA34 BD E61C        3325:          JSR   SCR
FA37 BD E44E        3326:          JSR   AT
FA3A BD F399        3327:          JSR   PLINE
FA3D BD E3F7        3328:          JSR   DROP
FA40 39             3329:          RTS
                    3330: *
FA41 C6             3331:          FCB   $C6
FA42 45             3332:          FCC   "EDITO"
FA43 44 49
FA45 54 4F
FA47 D2             3333:          FCB   $D2
FA48 FA 1B          3334:          FDB   LINE-7
FA4A BD E9C5        3335: EDITOR   JSR   DODOES
FA4D 7E EFD2        3336:          JMP   DOVOC
FA50 81 A0          3337:          FDB   $81A0
FA52 FD 2C          3338:          FDB   C-4
FA54 20 12          3339:          FDB   FORTH+10
                    3340: *
FA56 85             3341:          FCB   $85
FA57 57             3342:          FCC   "WHER"
FA58 48 45
FA5A 52
FA5B C5             3343:          FCB   $C5
FA5C FA 41          3344:          FDB   EDITOR-9
FA5E BD E414        3345: WHERE    JSR   DUP
FA61 BD E57C        3346:          JSR   BSCR
FA64 BD F175        3347:          JSR   SLASH
FA67 BD E414        3348:          JSR   DUP
FA6A BD E61C        3349:          JSR   SCR
FA6D BD E46E        3350:          JSR   STORE
```

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```
FA70 BD EA64 3351:          JSR   PDOTQ
FA73 06      3352:          FCB   6
FA74 53      3353:          FCC   "SCR # "
FA75 43 52
FA77 20 23
FA79 20
FA7A BD E93D 3354:          JSR   DEC
FA7D BD F814 3355:          JSR   DOT
FA80 BD E401 3356:          JSR   SWAP
FA83 BD F9F0 3357:          JSR   CL
FA86 BD F164 3358:          JSR   SLMOD
FA89 BD F9F0 3359:          JSR   CL
FA8C BD F157 3360:          JSR   STAR
FA8F BD E745 3361:          JSR   ROT
FA92 BD F314 3362:          JSR   BLOCK
FA95 BD E399 3363:          JSR   PLUS
FA98 BD E21D 3364:          JSR   CR
FA9B BD F9F0 3365:          JSR   CL
FA9E BD E9EB 3366:          JSR   TYPE
FAA1 BD E21D 3367:          JSR   CR
FAA4 BD E6CA 3368:          JSR   HERE
FAA7 BD E45E 3369:          JSR   CAT
FAAA BD E707 3370:          JSR   SUB
FAAD BD F715 3371:          JSR   SPACES
FAB0 BD E044 3372:          JSR   CLITER
FAB3 5E      3373:          FCB   $5E
FAB4 BD E1DC 3374:          JSR   EMIT
FAB7 BD FA4A 3375:          JSR   EDITOR
FABA BD F00A 3376:          JSR   QUIT
FABD 39      3377:          RTS
             3378: *
FABE 87      3379:          FCB   $87
FABF 23      3380:          FCC   "#LOCAT"
FAC0 4C 4F
FAC2 43 41
FAC4 54
FAC5 C5      3381:          FCB   $C5
FAC6 20 2D   3382:          FDB   TASK-7
FAC8 BD E68C 3383: NLOC     JSR   RNUM
FACB BD E44E 3384:          JSR   AT
FACE BD F9F0 3385:          JSR   CL
FAD1 BD F164 3386:          JSR   SLMOD
FAD4 39      3387:          RTS
             3388: *
FAD5 85      3389:          FCB   $85
FAD6 23      3390:          FCC   "#LEA"
FAD7 4C 45
FAD9 41
FADA C4      3391:          FCB   $C4
FADB FA BE   3392:          FDB   NLOC-10
FADD BD FAC8 3393: NLEAD    JSR   NLOC
FAE0 BD FA22 3394:          JSR   LINE
FAE3 BD E401 3395:          JSR   SWAP
FAE6 39      3396:          RTS
             3397: *
FAE7 84      3398:          FCB   $84
FAE8 23      3399:          FCC   "#LA"
FAE9 4C 41
FAEB C7      3400:          FCB   $C7
FAEC FA D5   3401:          FDB   NLEAD-8
```

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```
FAEE BD FADD 3402: NLAG   JSR   NLEAD
FAF1 BD E414 3403:        JSR   DUP
FAF4 BD E345 3404:        JSR   TOR
FAF7 BD E399 3405:        JSR   PLUS
FAFA BD F9F0 3406:        JSR   CL
FAFD BD E358 3407:        JSR   FROMR
FB00 BD E707 3408:        JSR   SUB
FB03 39      3409:        RTS
             3410: *
FB04 85      3411:        FCB   $85
FB05 2D      3412:        FCC   "-MOV"
FB06 4D 4F
FB08 56
FB09 C5      3413:        FCB   $C5
FB0A FA E7   3414:        FDB   NLAG-7
FB0C BD FA22 3415: MMOVE  JSR   LINE
FB0F BD F9F0 3416:        JSR   CL
FB12 BD E22D 3417:        JSR   CMOVE
FB15 BD F24E 3418:        JSR   UPDATE
FB18 39      3419:        RTS
             3420: *
FB19 81      3421:        FCB   $81
FB1A C8      3422:        FCB   $C8
FB1B FB 04   3423:        FDB   MMOVE-8
FB1D BD FA22 3424: H      JSR   LINE
FB20 BD EC4A 3425:        JSR   PAD
FB23 BD E6B0 3426:        JSR   ONEP
FB26 BD F9F0 3427:        JSR   CL
FB29 BD E414 3428:        JSR   DUP
FB2C BD EC4A 3429:        JSR   PAD
FB2F BD E482 3430:        JSR   CSTORE
FB32 BD E22D 3431:        JSR   CMOVE
FB35 39      3432:        RTS
             3433: *
FB36 81      3434:        FCB   $81
FB37 C5      3435:        FCB   $C5
FB38 FB 19   3436:        FDB   H-4
FB3A BD FA22 3437: ER     JSR   LINE
FB3D BD F9F0 3438:        JSR   CL
FB40 BD EC21 3439:        JSR   BLANKS
FB43 BD F24E 3440:        JSR   UPDATE
FB46 39      3441:        RTS
             3442: *
FB47 81      3443:        FCB   $81
FB48 D3      3444:        FCB   $D3
FB49 FB 36   3445:        FDB   ER-4
FB4B BD E414 3446: S      JSR   DUP
FB4E BD E52C 3447:        JSR   ONE
FB51 BD E707 3448:        JSR   SUB
FB54 BD E044 3449:        JSR   CLITER
FB57 0E      3450:        FCB   $E
FB58 BD E0C1 3451:        JSR   XDO
FB5B BD E0DA 3452: S2     JSR   I
FB5E BD FA22 3453:        JSR   LINE
FB61 BD E0DA 3454:        JSR   I
FB64 BD E6B0 3455:        JSR   ONEP
FB67 BD FB0C 3456:        JSR   MMOVE
FB6A BD E02C 3457:        JSR   LIT
FB6D FF FF   3458:        FDB   $FFFF
FB6F BD E08B 3459:        JSR   XPLOOP
```

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FB72 27 E7    3460:          BEQ    S2
FB74 BD FB3A  3461:          JSR    ER
FB77 39       3462:          RTS
              3463: *
FB78 81       3464:          FCB    $81
FB79 C4       3465:          FCB    $C4
FB7A FB 47    3466:          FDB    S-4
FB7C BD E414  3467: DEL      JSR    DUP
FB7F BD FB1D  3468:          JSR    H
FB82 BD E044  3469:          JSR    CLITER
FB85 0F       3470:          FCB    $F
FB86 BD E414  3471:          JSR    DUP
FB89 BD E745  3472:          JSR    ROT
FB8C BD E0C1  3473:          JSR    XDO
FB8F BD E0DA  3474: DEL2     JSR    I
FB92 BD E6B0  3475:          JSR    ONEP
FB95 BD FA22  3476:          JSR    LINE
FB98 BD E0DA  3477:          JSR    I
FB9B BD FB0C  3478:          JSR    MMOVE
FB9E BD E07C  3479:          JSR    XLOOP
FBA1 27 EC    3480:          BEQ    DEL2
FBA3 BD FB3A  3481:          JSR    ER
FBA6 39       3482:          RTS
              3483: *
FBA7 81       3484:          FCB    $81
FBA8 CD       3485:          FCB    $CD
FBA9 FB 78    3486:          FDB    DEL-4
FBAB BD E68C  3487: M        JSR    RNUM
FBAE BD E420  3488:          JSR    PSTORE
FBB1 BD E21D  3489:          JSR    CR
FBB4 BD E75A  3490:          JSR    SPACE
FBB7 BD FADD  3491:          JSR    NLEAD
FBBA BD E9EB  3492:          JSR    TYPE
FBBD BD E044  3493:          JSR    CLITER
FBC0 5F       3494:          FCB    $5F
FBC1 BD E1DC  3495:          JSR    EMIT
FBC4 BD FAEE  3496:          JSR    NLAG
FBC7 BD E9EB  3497:          JSR    TYPE
FBCA BD FAC8  3498:          JSR    NLOC
FBCD BD F814  3499:          JSR    DOT
FBD0 BD E3F7  3500:          JSR    DROP
FBD3 39       3501:          RTS
              3502: *
FBD4 81       3503:          FCB    $81
FBD5 D4       3504:          FCB    $D4
FBD6 FB A7    3505:          FDB    M-4
FBD8 BD E414  3506: T        JSR    DUP
FBDB BD F9F0  3507:          JSR    CL
FBDE BD F157  3508:          JSR    STAR
FBE1 BD E68C  3509:          JSR    RNUM
FBE4 BD E46E  3510:          JSR    STORE
FBE7 BD E414  3511:          JSR    DUP
FBEA BD FB1D  3512:          JSR    H
FBED BD E523  3513:          JSR    ZERO
FBF0 BD FBAB  3514:          JSR    M
FBF3 39       3515:          RTS
              3516: *
FBF4 81       3517:          FCB    $81
FBF5 CC       3518:          FCB    $CC
FBF6 FB D4    3519:          FDB    T-4
```

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```
FBF8 BD E61C 3520: L      JSR   SCR
FBFB BD E44E 3521:        JSR   AT
FBFE BD F82D 3522:        JSR   LIST
FC01 BD E523 3523:        JSR   ZERO
FC04 BD FBAB 3524:        JSR   M
FC07 39      3525:        RTS
             3526: *
FC08 81      3527:        FCB   $81
FC09 D2      3528:        FCB   $D2
FC0A FB F4   3529:        FDB   L-4
FC0C BD EC4A 3530: REP    JSR   PAD
FC0F BD E6B0 3531:        JSR   ONEP
FC12 BD E401 3532:        JSR   SWAP
FC15 BD FB0C 3533:        JSR   MMOVE
FC18 39      3534:        RTS
             3535: *
FC19 81      3536:        FCB   $81
FC1A D0      3537:        FCB   $D0
FC1B FC 08   3538:        FDB   REP-4
FC1D BD E52C 3539: P      JSR   ONE
FC20 BD F9FC 3540:        JSR   TEXT
FC23 BD FC0C 3541:        JSR   REP
FC26 39      3542:        RTS
             3543: *
FC27 81      3544:        FCB   $81
FC28 C9      3545:        FCB   $C9
FC29 FC 19   3546:        FDB   P-4
FC2B BD E414 3547: INS    JSR   DUP
FC2E BD FB4B 3548:        JSR   S
FC31 BD FC0C 3549:        JSR   REP
FC34 39      3550:        RTS
             3551: *
FC35 83      3552:        FCB   $83
FC36 54      3553:        FCC   "TO"
FC37 4F
FC38 D0      3554:        FCB   $D0
FC39 FC 27   3555:        FDB   INS-4
FC3B BD E523 3556: TOP    JSR   ZERO
FC3E BD E68C 3557:        JSR   RNUM
FC41 BD E46E 3558:        JSR   STORE
FC44 39      3559:        RTS
             3560: *
FC45 85      3561:        FCB   $85
FC46 43      3562:        FCC   "CLEA"
FC47 4C 45
FC49 41
FC4A D2      3563:        FCB   $D2
FC4B FC 35   3564:        FDB   TOP-6
FC4D BD E61C 3565: CLEAR  JSR   SCR
FC50 BD E46E 3566:        JSR   STORE
FC53 BD E044 3567:        JSR   CLITER
FC56 10      3568:        FCB   $10
FC57 BD E523 3569:        JSR   ZERO
FC5A BD E0C1 3570:        JSR   XDO
FC5D BD E0DA 3571: CL2    JSR   I
FC60 BD FB3A 3572:        JSR   ER
FC63 BD E07C 3573:        JSR   XLOOP
FC66 27 F5   3574:        BEQ   CL2
FC68 39      3575:        RTS
             3576: *
```

```
FC69 85       3577:          FCB   $85
FC6A 46       3578:          FCC   "FLUS"
FC6B 4C 55
FC6D 53
FC6E C8       3579:          FCB   $C8
FC6F FC 45    3580:          FDB   CLEAR-8
FC71 BD E044  3581: FLUSH    JSR   CLITER
FC74 08       3582:          FCB   8
FC75 BD E523  3583:          JSR   ZERO
FC78 BD E0C1  3584:          JSR   XDO
FC7B BD E02C  3585: FL2      JSR   LIT
FC7E 7F FF    3586:          FDB   $7FFF
FC80 BD F2B4  3587:          JSR   BUFFER
FC83 BD E3F7  3588:          JSR   DROP
FC86 BD E07C  3589:          JSR   XLOOP
FC89 27 F0    3590:          BEQ   FL2
FC8B 39       3591:          RTS
              3592: *
FC8C 84       3593:          FCB   $84
FC8D 43       3594:          FCC   "COP"
FC8E 4F 50
FC90 D9       3595:          FCB   $D9
FC91 FC 69    3596:          FDB   FLUSH-8
FC93 BD E57C  3597: COPY     JSR   BSCR
FC96 BD F157  3598:          JSR   STAR
FC99 BD E62A  3599:          JSR   OFSET
FC9C BD E44E  3600:          JSR   AT
FC9F BD E399  3601:          JSR   PLUS
FCA2 BD E401  3602:          JSR   SWAP
FCA5 BD E57C  3603:          JSR   BSCR
FCA8 BD F157  3604:          JSR   STAR
FCAB BD E57C  3605:          JSR   BSCR
FCAE BD E3E9  3606:          JSR   OVER
FCB1 BD E399  3607:          JSR   PLUS
FCB4 BD E401  3608:          JSR   SWAP
FCB7 BD E0C1  3609:          JSR   XDO
FCBA BD E414  3610: COPY2    JSR   DUP
FCBD BD E0DA  3611:          JSR   I
FCC0 BD F314  3612:          JSR   BLOCK
FCC3 BD E535  3613:          JSR   TWO
FCC6 BD E707  3614:          JSR   SUB
FCC9 BD E46E  3615:          JSR   STORE
FCCC BD E6B0  3616:          JSR   ONEP
FCCF BD F24E  3617:          JSR   UPDATE
FCD2 BD E07C  3618:          JSR   XLOOP
FCD5 27 E3    3619:          BEQ   COPY2
FCD7 BD E3F7  3620:          JSR   DROP
FCDA BD FC71  3621:          JSR   FLUSH
FCDD 39       3622:          RTS
              3623: *
FCDE 86       3624:          FCB   $86
FCDF 44       3625:          FCC   "DELET"
FCE0 45 4C
FCE2 45 54
FCE4 C5       3626:          FCB   $C5
FCE5 FC 8C    3627:          FDB   COPY-7
FCE7 BD E345  3628: DELETE   JSR   TOR
FCEA BD FAEE  3629:          JSR   NLAG
FCED BD E399  3630:          JSR   PLUS
FCF0 BD E36A  3631:          JSR   R
```

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```
FCF3 BD E707 3632:          JSR   SUB
FCF6 BD FAEE 3633:          JSR   NLAG
FCF9 BD E36A 3634:          JSR   R
FCFC BD E3C2 3635:          JSR   MINUS
FCFF BD E68C 3636:          JSR   RNUM
FD02 BD E420 3637:          JSR   PSTORE
FD05 BD FADD 3638:          JSR   NLEAD
FD08 BD E399 3639:          JSR   PLUS
FD0B BD E401 3640:          JSR   SWAP
FD0E BD E22D 3641:          JSR   CMOVE
FD11 BD E358 3642:          JSR   FROMR
FD14 BD EC21 3643:          JSR   BLANKS
FD17 BD F24E 3644:          JSR   UPDATE
FD1A 39      3645:          RTS
             3646: *
FD1B 81      3647:          FCB   $81
FD1C C2      3648:          FCB   $C2
FD1D FC DE   3649:          FDB   DELETE-9
FD1F BD EC4A 3650: B        JSR   PAD
FD22 BD E45E 3651:          JSR   CAT
FD25 BD E3C2 3652:          JSR   MINUS
FD28 BD FBAB 3653:          JSR   M
FD2B 39      3654:          RTS
             3655: *
FD2C 81      3656:          FCB   $81
FD2D C3      3657:          FCB   $C3
FD2E FD 1B   3658:          FDB   B-4
FD30 BD E52C 3659: C        JSR   ONE
FD33 BD F9FC 3660:          JSR   TEXT
FD36 BD EC4A 3661:          JSR   PAD
FD39 BD E9D7 3662:          JSR   COUNT
FD3C BD FAEE 3663:          JSR   NLAG
FD3F BD E745 3664:          JSR   ROT
FD42 BD E3E9 3665:          JSR   OVER
FD45 BD E767 3666:          JSR   MIN
FD48 BD E345 3667:          JSR   TOR
FD4B BD E36A 3668:          JSR   R
FD4E BD E68C 3669:          JSR   RNUM
FD51 BD E420 3670:          JSR   PSTORE
FD54 BD E36A 3671:          JSR   R
FD57 BD E707 3672:          JSR   SUB
FD5A BD E345 3673:          JSR   TOR
FD5D BD E414 3674:          JSR   DUP
FD60 BD E6CA 3675:          JSR   HERE
FD63 BD E36A 3676:          JSR   R
FD66 BD E22D 3677:          JSR   CMOVE
FD69 BD E6CA 3678:          JSR   HERE
FD6C BD FADD 3679:          JSR   NLEAD
FD6F BD E399 3680:          JSR   PLUS
FD72 BD E358 3681:          JSR   FROMR
FD75 BD E22D 3682:          JSR   CMOVE
FD78 BD E358 3683:          JSR   FROMR
FD7B BD E22D 3684:          JSR   CMOVE
FD7E BD F24E 3685:          JSR   UPDATE
FD81 BD E523 3686:          JSR   ZERO
FD84 BD FBAB 3687:          JSR   M
FD87 39      3688:          RTS
             3689: *
FD88 82      3690:          FCB   $82
FD89 50      3691:          FCC   "P"
```

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```
FD8A AE       3692:          FCB   $AE
FD8B FA 56    3693:          FDB   WHERE-8
FD8D BD E044  3694: PDOT     JSR   CLITER
FD90 40       3695:          FCB   $40
FD91 BD E535  3696:          JSR   TWO
FD94 BD E482  3697:          JSR   CSTORE
FD97 39       3698:          RTS
              3699: *
FD98 83       3700:          FCB   $83
FD99 4D       3701:          FCC   "MO"
FD9A 4F
FD9B CE       3702:          FCB   $CE
FD9C FD 88    3703:          FDB   PDOT-5
FD9E 7E FE86  3704: MON      JMP   START
FDA1 39       3705:          RTS                  Dummy
              3706: *
FDA2 84       3707:          FCB   $84
FDA3 4C       3708:          FCC   "LIN"
FDA4 49 4E
FDA6 CB       3709:          FCB   $CB
FDA7 FD 98    3710:          FDB   MON-6
FDA9 BD E53E  3711: LINK     JSR   THREE
FDAC BD F157  3712:          JSR   STAR
FDAF BD E044  3713:          JSR   CLITER
FDB2 DO       3714:          FCB   $DO
FDB3 BD E399  3715:          JSR   PLUS
FDB6 BD E414  3716:          JSR   DUP
FDB9 BD E044  3717:          JSR   CLITER
FDBC 7E       3718:          FCB   $7E
FDBD BD E401  3719:          JSR   SWAP
FDC0 BD E482  3720:          JSR   CSTORE
FDC3 BD E6B0  3721:          JSR   ONEP
FDC6 BD F545  3722:          JSR   TICK
FDC9 BD E401  3723:          JSR   SWAP
FDCC BD E46E  3724:          JSR   STORE
FDCF 39       3725:          RTS
              3726: *
FDD0 84       3727:          FCB   $84
FDD1 4E       3728:          FCC   "NOO"
FDD2 4F 4F
FDD4 D0       3729:          FCB   $DO
FDD5 FD A2    3730:          FDB   LINK-7
FDD7 39       3731: NOOP     RTS
              3732: *
0800          3733: BUB      EQU   $0800
              3734: *
FDD8 36       3735: BUBBLE   PSH A
FDD9 B6 0802  3736:          LDA A BUB+2
FDDC 85 01    3737:          BIT A #01
FDDE 27 04    3738:          BEQ   BB1
FDE0 C6 20    3739:          LDA B #$20
FDE2 32       3740: BB0      PUL A
FDE3 39       3741:          RTS
FDE4 5D       3742: BB1      TST B
FDE5 27 FB    3743:          BEQ   BB0
FDE7 5A       3744:          DEC B
FDE8 27 07    3745:          BEQ   READ
FDEA 5A       3746:          DEC B
FDEB 27 45    3747:          BEQ   WRITE
FDED C6 21    3748:          LDA B #$21
```

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```
FDEF 20 F1    3749:          BRA    BBO
FDF1 EC 00    3750: READ     FDB    $EC00        LDD 0,X
FDF3 B7 0804  3751:          STA A  BUB+4
FDF6 F7 0805  3752:          STA B  BUB+5
FDF9 CC       3753:          FCB    $CC          LDD #
FDFA 00 01    3754:          FDB    1
FDFC B7 0806  3755:          STA A  BUB+6
FDFF F7 0807  3756:          STA B  BUB+7
FE02 EE 02    3757:          LDX    2,X
FE04 86 05    3758:          LDA A  #5
FE06 B7 0801  3759:          STA A  BUB+1
FE09 B6 0802  3760: RD1      LDA A  BUB+2
FE0C 85 01    3761:          BIT A  #1
FE0E 26 F9    3762:          BNE    RD1
FE10 86 01    3763:          LDA A  #1
FE12 B7 0801  3764:          STA A  BUB+1
FE15 F6 0802  3765: RD2      LDA B  BUB+2
FE18 2B 0C    3766:          BMI    RD3
FE1A C5 20    3767:          BIT B  #$20
FE1C 27 F7    3768:          BEQ    RD2
FE1E B6 0800  3769:          LDA A  BUB
FE21 A7 00    3770:          STA A  0,X
FE23 08       3771:          INX
FE24 20 EF    3772:          BRA    RD2
FE26 C5 02    3773: RD3      BIT B  #2
FE28 26 03    3774:          BNE    RDERR
FE2A 5F       3775:          CLR B
FE2B 32       3776:          PUL A
FE2C 39       3777:          RTS
FE2D F6 0803  3778: RDERR    LDA B  BUB+3
FE30 32       3779:          PUL A
FE31 39       3780:          RTS
              3781: *
FE32 EC 00    3782: WRITE    FDB    $EC00        LDD 0,X
FE34 B7 0804  3783:          STA A  BUB+4
FE37 F7 0805  3784:          STA B  BUB+5
FE3A CC       3785:          FCB    $CC          LDD #
FE3B 00 01    3786:          FDB    1
FE3D B7 0806  3787:          STA A  BUB+6
FE40 F7 0807  3788:          STA B  BUB+7
FE43 EE 02    3789:          LDX    2,X
FE45 86 06    3790:          LDA A  #6
FE47 B7 0801  3791:          STA A  BUB+1
FE4A B6 0802  3792: WT1      LDA A  BUB+2
FE4D 85 01    3793:          BIT A  #1
FE4F 26 F9    3794:          BNE    WT1
FE51 86 02    3795:          LDA A  #2
FE53 B7 0801  3796:          STA A  BUB+1
FE56 F6 0802  3797: WT2      LDA B  BUB+2
FE59 2B 0C    3798:          BMI    WT3
FE5B C5 40    3799:          BIT B  #$40
FE5D 27 F7    3800:          BEQ    WT2
FE5F A6 00    3801:          LDA A  0,X
FE61 B7 0800  3802:          STA A  BUB
FE64 08       3803:          INX
FE65 20 EF    3804:          BRA    WT2
FE67 C5 02    3805: WT3      BIT B  #2
FE69 26 03    3806:          BNE    WTERR
FE6B 5F       3807:          CLR B
FE6C 32       3808:          PUL A
```

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```
FE6D 39       3809:          RTS
FE6E F6 0803  3810: WTERR    LDA B BUB+3
FE71 32       3811:          PUL A
FE72 39       3812:          RTS
              3813: *
              3814: *
              3815: *
              3816: * MONITOR
              3817: *
00EF          3818: STACK    EQU   $00EF
00FA          3819:          ORG   $00FA
00FA          3820: XTEMPM   RMB   2
00FC          3821: SP       RMB   2
00FE          3822: XHI      RMB   1
00FF          3823: XLOW     RMB   1
              3824: *
FE7E          3825:          ORG   $FE7E
              3826: *
FE7E CC       3827: FTHSTR   FCB   $CC          LDD #
FE7F 0C 0A    3828:          FDB   $0C0A
FE81 DD       3829:          FCB   $DD          STD
FE82 10       3830:          FCB   ACIAC-1
FE83 7E E001  3831:          JMP   ORIG+1
FE86 8E 00EF  3832: START    LDS   #STACK
FE89 9F FC    3833:          STS   SP
FE8B CC       3834:          FCB   $CC          LDD #
FE8C 0C 0A    3835:          FDB   $0C0A
FE8E DD       3836:          FCB   $DD          STD
FE8F 10       3837:          FCB   ACIAC-1
FE90 9E FC    3838: CONTRL   LDS   SP
FE92 CE FFDA  3839:          LDX   #MESSG1
FE95 BD FF09  3840:          JSR   JDATA1
FE98 BD FF08  3841:          JSR   PDATA3
FE9B BD FF10  3842:          JSR   INCH
FE9E 16       3843:          TAB
FE9F BD FF62  3844:          JSR   OUTS
FEA2 CE FFE2  3845:          LDX   #FCTABL
FEA5 E1 00    3846: NXTCHR   CMP B 0,X
FEA7 27 0A    3847:          BEQ   GOODCH
FEA9 08       3848:          INX
FEAA 08       3849:          INX
FEAB 08       3850:          INX
FEAC 8C FFEE  3851:          CPX   #FCTBEN
FEAF 26 F4    3852:          BNE   NXTCHR
FEB1 20 DD    3853:          BRA   CONTRL
FEB3 EE 01    3854: GOODCH   LDX   1,X
FEB5 6E 00    3855:          JMP   0,X
FEB7 8D 57    3856: INHEX    BSR   INCH
FEB9 80 30    3857: INHEX2   SUB A #'0
FEBB 2B D3    3858:          BMI   CONTRL
FEBD 81 09    3859:          CMP A #9
FEBF 2F 0A    3860:          BLE   IN1HG
FEC1 81 11    3861:          CMP A #$11
FEC3 2B CB    3862:          BMI   CONTRL
FEC5 81 16    3863:          CMP A #$16
FEC7 2E C7    3864:          BGT   CONTRL
FEC9 80 07    3865:          SUB A #7
FECB 39       3866: IN1HG    RTS
FECC 86 07    3867: ERRORM   LDA A #7
FECE 8D 2B    3868:          BSR   OUTCH
```

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```
FED0 86 3F    3869:          LDA A #'?
FED2 8D 27    3870:          BSR   OUTCH
FED4 20 BA    3871:          BRA   CONTRL
FED6 8D 09    3872: BADDR    BSR   BYTE
FED8 97 FE    3873:          STA A XHI
FEDA 8D 05    3874:          BSR   BYTE
FEDC 97 FF    3875:          STA A XLOW
FEDE DE FE    3876:          LDX   XHI
FEE0 39       3877:          RTS
FEE1 8D D4    3878: BYTE     BSR   INHEX
FEE3 48       3879: BYTE2    ASL A
FEE4 48       3880:          ASL A
FEE5 48       3881:          ASL A
FEE6 48       3882:          ASL A
FEE7 16       3883:          TAB
FEE8 8D CD    3884:          BSR   INHEX
FEEA 1B       3885:          ABA
FEEB 16       3886:          TAB
FEEC 39       3887:          RTS
FEED 44       3888: OUTHL    LSR A
FEEE 44       3889:          LSR A
FEEF 44       3890:          LSR A
FEF0 44       3891:          LSR A
FEF1 84 0F    3892: OUTHR    AND A #$F
FEF3 8B 30    3893:          ADD A #'0
FEF5 81 39    3894:          CMP A #'9
FEF7 23 02    3895:          BLS   OUTCH
FEF9 8B 07    3896:          ADD A #7
FEFB 37       3897: OUTCH    PSH B
FEFC D6 11    3898: OUTC1    LDA B ACIAC
FEFE C5 20    3899:          BIT B #$20
FF00 27 FA    3900:          BEQ   OUTC1
FF02 97 13    3901:          STA A ACIAD+1
FF04 33       3902:          PUL B
FF05 39       3903:          RTS
FF06 8D F3    3904: PDATA2   BSR   OUTCH
FF08 08       3905: PDATA3   INX
FF09 A6 00    3906: JDATA1   LDA A 0,X
FF0B 81 04    3907:          CMP A #4
FF0D 26 F7    3908:          BNE   PDATA2
FF0F 39       3909:          RTS
FF10 96 11    3910: INCH     LDA A ACIAC
FF12 48       3911:          ASL A
FF13 24 FB    3912:          BCC   INCH
FF15 96 12    3913:          LDA A ACIAD
FF17 84 7F    3914:          AND A #$7F
FF19 20 E0    3915:          BRA   OUTCH
FF1B 8D 42    3916: CHANGE   BSR   BADDRS
FF1D DE FE    3917:          LDX   XHI
FF1F 8D 3A    3918:          BSR   OUT2HS
FF21 09       3919:          DEX
FF22 8D EC    3920: CHA1     BSR   INCH
FF24 81 0A    3921:          CMP A #$A
FF26 27 19    3922:          BEQ   LF
FF28 81 5E    3923:          CMP A #$5E
FF2A 27 0E    3924:          BEQ   UA
FF2C BD FEB9  3925:          JSR   INHEX2
FF2F 8D B2    3926:          BSR   BYTE2
FF31 A7 00    3927:          STA A 0,X
FF33 A1 00    3928:          CMP A 0,X
```

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```
FF35 27 EB    3929:          BEQ    CHA1
FF37 7E FECC  3930:          JMP    ERRORM
FF3A 86 0A    3931: UA       LDA A  #$A
FF3C 8D BD    3932:          BSR    OUTCH
FF3E 09       3933:          DEX
FF3F 20 01    3934:          BRA    LF1
FF41 08       3935: LF       INX
FF42 DF FE    3936: LF1      STX    XHI
FF44 CE FFDB  3937:          LDX    #MESSG1+1
FF47 8D C0    3938:          BSR    JDATA1
FF49 CE 00FE  3939:          LDX    #XHI
FF4C 8D 0B    3940:          BSR    OUT4HS
FF4E 20 CD    3941:          BRA    CHANGE+2
FF50 A6 00    3942: OUT2H    LDA A  0,X
FF52 08       3943:          INX
FF53 36       3944: OUT2HA   PSH A
FF54 8D 97    3945:          BSR    OUTHL
FF56 32       3946:          PUL A
FF57 20 98    3947:          BRA    OUTHR
FF59 8D F5    3948: OUT4HS   BSR    OUT2H
FF5B 8D F3    3949: OUT2HS   BSR    OUT2H
FF5D 20 03    3950:          BRA    OUTS
FF5F BD FED6  3951: BADDRS   JSR    BADDR
FF62 86 20    3952: OUTS     LDA A  #$20
FF64 20 95    3953:          BRA    OUTCH
FF66 CE FFDA  3954: PRINT    LDX    #MESSG1
FF69 8D 9E    3955:          BSR    JDATA1
FF6B DE FC    3956:          LDX    SP
FF6D 08       3957:          INX
FF6E 8D EB    3958:          BSR    OUT2HS
FF70 8D E9    3959:          BSR    OUT2HS
FF72 8D E7    3960:          BSR    OUT2HS
FF74 8D E3    3961:          BSR    OUT4HS
FF76 8D E1    3962:          BSR    OUT4HS
FF78 CE 00FC  3963:          LDX    #SP
FF7B 20 DC    3964:          BRA    OUT4HS
FF7D 37       3965: GO       PSH B
FF7E BD FF5F  3966:          JSR    BADDRS
FF81 0F       3967:          SEI
FF82 6E 00    3968:          JMP    0,X
FF84 9F FC    3969: SWIENT   STS    SP
FF86 30       3970:          TSX
FF87 6D 06    3971:          TST    6,X
FF89 26 02    3972:          BNE    SW1
FF8B 6A 05    3973:          DEC    5,X
FF8D 6A 06    3974: SW1      DEC    6,X
FF8F BD FF66  3975: REG      JSR    PRINT
FF92 7E FE90  3976:          JMP    CONTRL
FF95 CE FFA0  3977: TRAP     LDX    #MESSG2
FF98 BD FF09  3978:          JSR    JDATA1
FF9B 9F FC    3979:          STS    SP
FF9D 30       3980:          TSX
FF9E 20 EF    3981:          BRA    REG
FFA0 54       3982: MESSG2   FCC    "TRAPPED AT "
FFA1 52 41
FFA3 50 50
FFA5 45 44
FFA7 20 41
FFA9 54 20
FFAB 04       3983:          FCB    4
```

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FFAC CE FFDA 3984: LCMD    LDX    #MESSG1
FFAF BD FF09 3985:         JSR    JDATA1
FFB2 BD FF5F 3986:         JSR    BADDRS
FFB5 BD FEE1 3987: LCMD1   JSR    BYTE
FFB8 A7 00   3988:         STA A  0,X
FFBA A1 00   3989:         CMP A  0,X
FFBC 27 03   3990:         BEQ    LCMD2
FFBE 7E FECC 3991:         JMP    ERRORM
FFC1 08      3992: LCMD2   INX
FFC2 DF FA   3993:         STX    XTEMPM
FFC4 86 0F   3994:         LDA A  #$F
FFC6 94 FB   3995:         AND A  XTEMPM+1
FFC8 26 EB   3996:         BNE    LCMD1
FFCA CE FFDA 3997:         LDX    #MESSG1
FFCD BD FF09 3998:         JSR    JDATA1
FFD0 CE 00FA 3999:         LDX    #XTEMPM
FFD3 BD FF59 4000:         JSR    OUT4HS
FFD6 DE FA   4001:         LDX    XTEMPM
FFD8 20 DB   4002:         BRA    LCMD1
FFDA 0A      4003: MESSG1  FCB    $A,$D,0,0,0,4,$2A,4
FFDB 0D 00
FFDD 00 00
FFDF 04 2A
FFE1 04
FFE2 4D      4004: FCTABL  FCC    "M"
FFE3 FF 1B   4005:         FDB    CHANGE
FFE5 52      4006:         FCC    "R"
FFE6 FF 8F   4007:         FDB    REG
FFE8 58      4008:         FCC    "X"
FFE9 FF 7D   4009:         FDB    GO
FFEB 4C      4010:         FCC    "L"
FFEC FF AC   4011:         FDB    LCMD
             4012: *
FFEE FF 95   4013: FCTBEN  FDB    TRAP
FFF0 00 D0   4014:         FDB    SCI
FFF2 00 D3   4015:         FDB    TOF
FFF4 00 D6   4016:         FDB    OCF
FFF6 00 D9   4017:         FDB    ICF
FFF8 00 DC   4018:         FDB    IRQ1
FFFA FF 84   4019:         FDB    SWIENT       SWI
FFFC FE 86   4020:         FDB    START        NMI
FFFE FE 7E   4021:         FDB    FTHSTR       RESET
             4022: *
             4023:         END
      NO ERROR(S) DETECTED


   SYMBOL TABLE:
ABORT   F055    ABS     F1DA    ABS2    F1E8    ACIAC   0011
ACIAD   0012    AGAIN   F679    ALLOT   E6D9    AND     E2D5
ARROW   F45C    AT      E44E    B       FD1F    BACK    F5C3
BACKSP  E00E    BADDR   FED6    BADDRS  FF5F    BASE    E661
BBO     FDE2    BB1     FDE4    BBUF    E56F    BCOMP   EECE
BDIGS   F737    BEGIN   F5DE    BL      E548    BLANKS  EC21
BLK     E5FC    BLOCK   F314    BLOCK3  F33D    BLOCK4  F363
BLOCK5  F386    BSCR    E57C    BUB     0800    BUBBLE  FDD8
BUFFER  F2B4    BUFFR2  F2C0    BUFFR3  F2F6    BUILDS  E98E
BYTE    FEE1    BYTE2   FEE3    C       FD30    CAT     E45E
CCOMM   E6F6    CENT    F081    CHA1    FF22    CHANGE  FF1B
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CL	F9F0	CL2	FC5D	CLEAR	FC4D	CLITER	E044
CMOV2	E241	CMOV3	E25A	CMOVE	E22D	COLD	F081
COLD2	F087	COLD3	F096	COLINT	E022	COLON	E495
COLUMS	E6A6	COMMA	E6E4	COMPIL	E8CF	CON	E4CE
CONTRL	FE90	CONTXT	E639	COPY	FC93	COPY2	FCBA
COUNT	E9D7	CR	E21D	CREAT2	EE80	CREATE	EE59
CSP	E682	CSTORE	E482	CURENT	E648	DABS	F1F0
DABS2	F1FE	DDOT	F806	DDOTR	F7D9	DDUP	E79E
DDUP2	E7A9	DEC	E93D	DEFIN	EFEA	DEL	FB7C
DEL2	FB8F	DELETE	FCE7	DELINT	E024	DFIND	ED95
DFIND2	EDC1	DIG	F77A	DIG2	F79C	DIGIT	E0EE
DIGIT0	E102	DIGIT1	E10A	DIGIT2	E10D	DIGS	F7AC
DLINE	F3C5	DLITE2	EF26	DLITER	EF12	DMINUS	E3D2
DO	F613	DOCON	E4E0	DODOES	E9C5	DOES	E9A3
DOT	F814	DOT0	EA82	DOT01	EAA8	DOT02	EAB4
DOTR	F7C6	DOUSER	E511	DOVAR	E4FD	DOVOC	EFD2
DP	E5E1	DPINIT	E01E	DPL	E66C	DPLMI	F976
DPLMI2	F981	DPLUS	E3A7	DRB	F4D9	DRIVE	F4E6
DRONE	F29F	DROP	E3F7	DRZERO	F28F	DTRAIL	EA26
DTRAL2	EA2F	DTRAL3	EA51	DTRAL4	EA57	DUP	E414
DWNCNT	0088	EDIGS	F746	EDITOR	FA4A	ELSE	F6DA
EMIT	E1DC	ENCL2	E193	ENCL3	E1A0	ENCL4	E1A3
ENCL5	E1B0	ENCL6	E1B6	ENCL7	E1BC	ENCL8	E1C0
ENCLOS	E18A	END	F66D	ENDIF	F5F0	EQUAL	E712
ER	FB3A	ERAM	F133	ERASE	EC11	ERROR	EDD8
ERROR2	EDE9	ERRORM	FECC	EXEC	E05D	EXPEC2	EB06
EXPEC3	EB45	EXPEC4	EB62	EXPEC5	EB65	EXPEC6	EB77
EXPECT	EAFA	FCTABL	FFE2	FCTBEN	FFEE	FENCE	E5D7
FENCIN	E01C	FILL	EBEA	FIRST	E555	FL2	FC7B
FLD	E677	FLUSH	FC71	FORGET	F561	FORTH	2008
FOUND	E16B	FROMR	E358	FTHSTR	FE7E	GO	FF7D
GOODCH	FEB3	GREAT	E738	H	FB1D	HERE	E6CA
HEX	E928	HLD	E697	HLFCYC	0082	HOLD	EC2F
I	E0DA	ICF	00D9	IDDOT	EE16	IF	F6B1
IMMED	EF8B	IN	E606	IN1HG	FECB	INCH	FF10
INDEX	F87F	INDEX2	F88B	INDEX3	F8AE	INHEX	FEB7
INHEX2	FEB9	INS	FC2B	INTER3	EF55	INTER4	EF58
INTER5	EF5A	INTER6	EF73	INTER7	EF79	INTERP	EF33
IOSTAT	4036	IR01	00DC	JDATA1	FF09	JMPTAB	F0EF
KEY	E1F6	KEY1	E1FB	L	FBF8	LATEST	E7E0
LBRAK	E8F5	LCMD	FFAC	LCMD1	FFB5	LCMD2	FFC1
LEAVE	E336	LESS	E71D	LESSF	E729	LESST	E72C
LESSX	E72E	LF	FF41	LF1	FF42	LFA	E7F0
LIMIT	E562	LINE	FA22	LINK	FDA9	LIST	F82D
LIST2	F853	LIT	E02C	LITER	EEF2	LITER2	EF06
LOAD	F419	LOOP	F627	M	FBAB	MAX	E782
MAX2	E793	MEMEND	E000	MEMTOP	DFFF	MESS	F3D9
MESS2	F402	MESS3	F404	MESS4	F411	MESSG1	FFDA
MESSG2	FFA0	MIN	E767	MIN2	E778	MINUS	E3C2
MMOVE	FB0C	MOD	F185	MON	FD9E	MSLASH	F9BC
MSMOD	F1B8	MSTAR	F998	MTBUF	F279	MUDFLG	0080
N	00E0	NBLK	0008	NFA	E7FD	NLAG	FAEE
NLEAD	FADD	NLOC	FAC8	NOOP	FDD7	NULL	EBA8
NULL2	EBDC	NULL3	EBE2	NUMB	ED25	NUMB1	ED4C
NUMB2	ED7E	NUMB3	ED8C	NXTCHR	FEA5	OCF	00D6
OFSET	E62A	ONE	E52C	ONEP	E6B0	OR	E2E5
ORIG	E000	OUT	E611	OUT2H	FF50	OUT2HA	FF53
OUT2HS	FF5B	OUT4HS	FF59	OUTC1	FEFC	OUTCH	FEFB
OUTHL	FEED	OUTHR	FEF1	OUTS	FF62	OVER	E3E9
OVRFWS	0084	P	FC1D	PABORT	EDCC	PAD	EC4A

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PAREN	EFFB	PBUF	F21D	PBUF2	F238	PCR	F4BC
PCR2	F4CA	PDATA2	FF06	PDATA3	FF08	PDOT	FD8D
PDOTQ	EA64	PEMIT	F481	PEMIT2	F485	PEMIT3	F48A
PFA	E813	PFIND	E11D	PFIND1	E12B	PFIND2	E13E
PFIND3	E154	PFIND4	E162	PFIND8	E15F	PFIND9	E164
PKEY	F49B	PLINE	F399	PLMI	F987	PLMI2	F992
PLOOP	F63F	PLUS	E399	PNUMB	ECC4	PNUMB3	ED13
PNUMB4	ED18	PORIG	E58B	PQTER	F4B1	PQTER2	F4BB
PREV	F211	PRINT	FF66	PSCODE	E952	PSTORE	E420
QCOMP	E853	QCSP	E895	QERR	E83A	QERR2	E847
QERR3	E84A	QEXEC	E86C	QLOAD	E8B4	QPAIRS	E883
QSTAC2	EADA	QSTAC3	EAF0	QSTACK	EABE	QTERM	E211
QUERY	EB8B	QUEST	F81F	QUIT	F00A	QUIT2	F016
QUIT3	F04A	R	E36A	RBRAK	E903	RD1	FE09
RD2	FE15	RD3	FE26	RDERR	FE2D	READ	FDF1
REG	FF8F	REND	2035	REP	FC0C	REPEAT	F693
RFORTH	F106	RINIT	E014	RNUM	E68C	ROT	E745
RPSTOR	E31D	RTASK	F132	RW	F4FA	RW2	F519
RW3	F51C	RW4	F540	RZERO	E5A3	S	FB4B
S2	FB5B	SCI	00D0	SCR	E61C	SCSP	E827
SEMI	E4B2	SEMIC	E974	SEMIS	E32A	SIGFLG	0086
SIGN	F763	SIGN2	F775	SINIT	E012	SLASH	F175
SLMOD	F164	SMUDGE	E917	SP	00FC	SPACE	E75A
SPACE2	F729	SPACE3	F731	SPACES	F715	SPAT	E307
SPSTOR	E312	SSLASH	F1A6	SSMOD	F194	STACK	00EF
STAR	F157	START	FE86	STATE	E655	STOD	F149
STORE	E46E	SUB	E707	SW1	FF8D	SWAP	E401
SWIENT	FF84	SZERO	E599	T	FBD8	TASK	2034
TEXT	F9FC	THEN	F60A	THREE	E53E	TIB	E5AE
TICK	F545	TOF	00D3	TOGGLE	E43A	TOP	FC3B
TOR	E345	TRAP	FF95	TRAV	E7B5	TRAV2	E7B8
TRIAD	F8BF	TRIAD2	F8DA	TRIAD3	F8EE	TWO	E535
TWOP	E6BC	TYPE	E9EB	TYPE2	E9FF	TYPE3	EA16
TYPE4	EA19	UA	FF3A	UNTIL	F657	UORIG	4000
UP	00F2	UPDATE	F24E	UPINIT	E010	USE	F205
USER	E50B	USL1	E2A5	USL2	E2AF	USL3	E2B2
USL4	E2B5	USL5	E2C3	USLASH	E29E	USTAR	E262
USTAR2	E284	USTAR3	E28A	VAR	E4F7	VLIST	F909
VLIST1	F91C	VLIST2	F943	VOCAB	EFA3	VOCINT	E020
VOCLIN	E5F1	WARM2	F0CF	WARN	E5CA	WENT	F0C9
WHERE	FA5E	WHILE	F705	WIDTH	E5BB	WORD	EC5C
WORD2	EC72	WORD3	EC78	WRITE	FE32	WT1	FE4A
WT2	FE56	WT3	FE67	WTERR	FE6E	XBASE	4026
XBLK	4016	XCOLUM	4034	XCONT	4020	XCSP	402C
XCURR	4022	XDELAY	4032	XDO	E0C1	XDP	4012
XDPL	4028	XFENCE	4010	XFLD	402A	XHI	00FE
XHLD	4030	XIN	4018	XLOOP	E07C	XLOW	00FF
XOFSET	401E	XOR	E2F6	XOUT	401A	XPLOF	E0A5
XPLONO	E0AB	XPLOOP	E08B	XPLOP2	E08F	XPLOPS	E09F
XPREV	4042	XRNUM	402E	XRZERO	4008	XSCR	401C
XSPZER	4006	XSTATE	4024	XTEMP	00F0	XTEMPM	00FA
XTIB	400A	XUSE	4040	XVOCL	4014	XWARN	400E
XWIDTH	400C	ZBRAN	E06E	ZBYES	E0B6	ZEQU	E37B
ZEQU2	E382	ZERO	E523	ZLESS	E38B	ZLESS2	E391

APPENDIX A2 PATSY MACHINE CODE LISTING

```
*ROLLING-BUFFER CODE
*-------------------
*
*The code part of an array created by
*ROLLING-BUFFER is :-
*    JSR ROLLBF
*    00 00 00
*    Address of pointer field in RAM
*    Address of last element
*
*The pointer field immediately precedes
*the array and contains the address of
*the next element to be accessed.
*
*
                N       EQU $E0 Scratch area
                XTEMP   EQU $F0

0000 DF F0      ROLLBF  STX XTEMP Save data stack pointer
0002 38                 PUL X     Copy return address which is
0003 3C                 PSH X     also the parameter pointer
0004 EE 03              LDX 3,X   X = the pointer field address
0006 EC 00              LDD 0,X   D = the next element address
0008 DD E0              STD N     Save it in scratch area
000A C3 0002            ADD D #2  Advance to next element
000D ED 00              STD 0,X   and store if back in pointer field
000F 38                 PUL X     Remove return address
0010 A3 05              SUB D 3,X last element's address?
0012 23 09              BLS RB1   Lower or same?
0014 EC 03              LDD 3,X   No. D = pointer field address
0016 EE 03              LDX 3,X   and so does X
0018 C3 0002            ADD D #2  First element address is 2 on from
001B ED 00              STD 0,X   pointer field. Now save it there.
001D DE F0      RB1     LDX XTEMP Recover data stack pointer
001F DC E0              LDD N     and element's address
0021 ED 00              STD 0,X   Push it onto the stack
0023 09                 DEX       and adjust the stack
0024 09                 DEX       pointer
0025 39                 RTS       Put here by RETURN

*Note. This is called as a subroutine but the return address is
*removed from the stack so when RTS is executed it is the
*underlying return address that is used.
*
*
*ARRAY+ CODE
*----------
*This is practically the same as for ROLLING-BUFFER
*

0000 DF F0      ARRAYP  STX XTEMP
0002 38                 PUL X
0003 3C                 PSH X
0004 EE 03              LDX 3,X
0006 EC 00              LDD 0,X
0008 DD E0              STD N
000A C3 0002            ADD D #2
000D ED 00              STD 0,X
000F 38                 PUL X
0010 A3 05              SUB D 5,X
```

```
0012 23 06            BLS ARP1
0014 EC 05            LDD 5,X Get last element's address
0016 EE 03            LDX 3,X X = pointer field
0018 ED 00            STD 0,X Point to last element
001A DE F0    ARP1    LDX XTEMP
001C DC E0            LDD N
001E ED 00            STD 0,X
0020 09               DEX
0021 09               DEX
0022 39               RTS
*
*
*TISR Timer interrupt service routine.
*----
*This routine counts down the whole number of counter cycles
*required by long delays.
*
              TIMCNT EQU $08 Timer control register.
              TIMOCR EQU $0B Timer o/p compare reg.
              OVFLWS EQU $84 No. of complete counter cycles
              CORRFG EQU $90 Small residual correction flag


0000 DC 08    TISR    LDD TIMCNT Dummy read
0002 DE 84            LDX OVFLWS
0004 27 05            BEQ TIS1    Down to zero yet?
0006 09               DEX         No. Decrement the count.
0007 DF 84            STX OVFLWS and store it back
0009 26 12            BNE TIS2    Has it become zero?
000B 96 08    TIS1    LDA A TIMCNT Yes. Read control reg.
000D 84 F7            AND A #$F7  and mask off interrupt
000F 97 08            STA A TIMCNT enable bit.
0011 7D 0091          TST CORRFG+1  Correction needed?
0014 27 07            BEQ TIS2    If no then skip
0016 DC 0B            LDD TIMOCR  Subtract the 128
0018 83 0080          SUB D #128  that was added by DELAY
001B 20 02            BRA TIS3
001D DC 0B    TIS2    LDD TIMOCR  Read TIMOCR and write to it
001F DD 0B    TIS3    STD TIMOCR  to clear the flag.
0021 3B               RTI         Put here by TFORTH RTI.
*
*
*SISR Signal interrupt service routine
*----
*
*The interrupt flag is cleared by first reading the control
*register then the timer i/p capture register.
*
              TIMICR EQU $0D
              SIGFLG EQU $86

0000 96 08    SISR    LDA A TIMCNT Read control reg.
0002 D6 0D            LDA B TIMICR  Dummy read TIMICR
0004 84 EF            AND A #$EF    Mask off interrupt
0006 97 08            STA A TIMCNT enable bit.
0008 4F               CLR A
0009 5F               CLR B
000A DD 86            STD SIGFLG   Clear SIGFLG
000C 3B               RTI           Put here by TFORTH RTI
```

```
*

*
*MSISR Mud sensor interrupt service routine
*-----
*
*Two interrupts vector here though the second should
*not occur.
*
*
               MUDFLG EQU $80 Set on optical switch interrupt
               ADCDAT EQU $1000 ADC data port
               ADCCNT EQU $1002 ADC control port

0000 B6 1002  MSISR  LDA A ADCCNT Get interrupt flag - MSB
0003 2B 05           BMI MS1      Is it set?
0005 B6 1000         LDA A ADCDAT No. Read to clear other
0008 20 07           BRA MS2      unused interrupt flag
000A B6 1000  MS1    LDA A ADCDAT Dummy read to clear flag
000D 86 FF           LDA A #$FF   Set MUDFLG
000F 97 80           STA A MUDFLG
0011 3B       MS2    RTI
*
*
*SERIAL Serial interrupt service routine
*------
*This interrupt should not happened
*
*
0000 96 11    SERIAL LDA A $11    Read serial interface control reg.
0002 84 EB           AND A #$EB   Mask off interupt enable bit
0004 97 11           STA A $11
0006 3B              RTI
*
*
*TIMER-O'FLOW interrupt service routine
*
*Should this accidently happen the double byte read of
*TIMCNT and the adjacent register ($09), the high byte
*of the timer followed by a write to TIMCNT will clear
*the interrrupt flag. The enable bit is also masked off.
*
*
0000 DC 08    TOF    LDD TIMCNT Get TIMOCR and read timer
0002 84 FB           AND A #$FB  Mask off interrupt
0004 97 08           STA A TIMCNT enable bit.
0006 3B              RTI
*
*
*SORT
*----
*
*The PING-LIST generated by PREPARE need not be in
*order of delay values. This routine compares adjacent
*values and swaps them if they are in the wrong order
*and progresses through the list. This is repeated from
*the start unless the previous pass resulted in no swaps.
*
0000 3C       SORT   PSH X Save data stack pointer
0001 86 01    SRT1   LDA A #1 Set pass flag
```

```
0003 36                 PSH A and save it.
0004 CE ****            LDX #PING-LIST+2 Start of list

0007 EC 00      SRT2    LDD 0,X Compare two values
0009 A3 02              SUB D 2,X
000B 2F 13              BLE SRT3 in order?
000D A6 00              LDA A 0,X No
000F E6 02              LDA B 2,X Swap them
0011 A7 02              STA A 2,X
0013 E7 00              STA B 0,X.
0015 A6 01              LDA A 1,X
0017 E6 03              LDA B 3,X
0019 A7 03              STA A 3,X
001B E7 01              STA B 1,X
001D 32                 PUL A Get pass flag
001E 4F                 CLR A Clear it
001F 36                 PSH A and save it again
0020 08                 INX Advance through list
0021 08                 INX
0022 8C ****            CPX #PING-LIST+16 End?
0025 26 E0              BNE SRT2 Try next pair if not
0027 32                 PUL A Yes. Get pass flag
0028 4D                 TST A Any swaps during this pass?
0029 27 D6              BEQ SRT1 If yes then try once more
002B 38                 PUL X No finished
002C 39                 RTS
*
*CHECK
*
*This checks for three possibilities.
*       Values less than 20 mSec. (or negative)
*       Values that are too large.
*       Values too close (< 20 mSec. apart)
*There are eight values in the list but room for 10.
*The 9th and 10th values are zeroed. The 9th acts as a
*delimiter in this routine and the 10th is left to terminate
*the PING-LIST.
*In the first phase values less than 20 are lost by shifting
*the whole list up.
*Values too large are then replaced by a maximum value.  It
*does not matter if there are more than one of these as the
*last phase will sort this out.
*Finally pairs of values are checked for a difference of less
*than 20 where-upon the second replaces the first.
*
0000 3C         CHECK   PSH X Save data stack pointer
0001 CE ****            LDX #PING-LIST
0004 4F                 CLR A
0005 5F                 CLR B
0006 ED 12              STD 18,X Add delimiter
0008 ED 14              STD 20,X Terminate list
000A 86 08              LDA A #8 No. of passes
000C 36                 PSH A
000D CE ****    CHK1    LDX #PING-LIST
0010 EC 02              LDD 2,X 1st entry
0012 83 0014            SUB D #20 Less than 20 mSecs?
0015 2A 10              BPL CHK3
0017 EC 04      CHK2    LDD 4,X Yes, shift remaining
0019 ED 02              STD 2,X values up the list
001B 08                 INX
```

```
001C 08                 INX
001D 8C ****            CPX #PING-LIST+16
0020 26 F5              BNE CHK2

0022 32                 PUL A Get No. of passes
0023 4A                 DEC A Try another pass?
0024 36                 PSH A
0025 26 E6              BNE CHK1 Last pass?
0027 32         CHK3    PUL A
0028 CE ****            LDX #PING-LIST
002B EC 02      CHK4    LDD 2,X If this is zero then
002D 26 07              BNE CHK5 whole list was <20
002F CC 07AD            LDD #1965 Set maximum delay
0032 ED 02              STD 2,X
0034 20 11              BRA CHK7 and skip to next phase
0036 83 0799    CHK5    SUB D #1945
0039 25 05              BCS CHK6 Greater than 1945?
003B CC 0799            LDD #1965 Set = maximum
003E ED 02              STD 2,X
0040 08         CHK6    INX
0041 08                 INX
0042 8C ****            CPX #PING-LIST+18
0045 26 E4              BNE CHK4 Until end of list
0047 CE ****    CHK7    LDX #PING-LIST
004A EC 04      CHK8    LDD 4,X Get 2nd value. If this
004C 27 1F              BEQ CHK12 is zero, we're finished
004E A3 02              SUB D 2,X Is it more than 19
0050 83 0013            SUB D #19 from previous?
0053 2A 11              BPL CHK11
0055 3C                 PSH X
0056 EC 04      CHK9    LDD 4,X Over-write previous with
0058 ED 02              STD 2,X it and shift the remainder
005A 27 07              BEQ CHK10 of the list up
005C 08                 INX
005D 08                 INX
005E 8C ****            CPX #PING-LIST+18
0061 26 F3              BNE CHK9
0063 38         CHK10   PUL X
0064 20 E4              BRA CHK8 Loop back until delimiter
0066 08         CHK11   INX      found
0067 08                 INX
0068 8C ****            CPX #PING-LIST+16
006B 26 DD              BNE CHK8
006D 38         CHK12   PUL X Recover data stack pointer
006E 39                 RTS
*
*
*SAMPLE
*------
*
*The ADC and multiplexer are accessed through a 16 bit parallel
*port. The least significant 12 lines are programmed as inputs
*from the ADC and 3 of the most significant bits are set-up as
*outputs to the multiplexer. The control line CA2 is used to
*switch the S&H chip while CB2 triggers the converter. The end
*of conversion is detected by CB1.
*
0000 EC 02      SAMPLE LDD 2,X Get channel No. in last
0002 58                ASL B   4 bits. Multiplexer
0003 58                ASL B   address lines are the
```

```
0004 58              ASL B   high 4 bits so
0005 58              ASL B   multiply by 16
0006 F7 1000         STA B ADCDAT Select channel
0009 B6 1002         LDA A ADCCNT

000C 84 37           AND A #$37 Turn S&H to
000E B7 1002         STA A ADCCNT   hold.
0011 7C 1000         INC ADCDAT+1 Dummy write triggers
0014 7D 1002  SM1    TST ADCCNT+1 conversion
0017 2A FB           BPL SM1 Finished yet?
0019 B6 1002         LDA A ADCCNT
001C 8A 08           ORA A #8 Turn S&H to
001E B7 1002         STA A ADCCNT  sample
0021 FC 1000         LDD ADCDAT Fetch data (12 bits)
0024 84 0F           AND A #%00001111 Mask off high 4 bits
0026 83 0800         SUB D #$800 0 volts = 1/2 F.S.
0029 43              COM A negate because converter
002A 50              NEG B uses negative logic
002B 26 01           BNE SM2
002D 4C              INC A
002E ED 02    SM2    STD 2,X Push result onto
0030 39              RTS     data stack and return.
*
*
*DELAY
*-----
*
*The first part of this routine waits for a previous delay
*to run out. If OVER-FLOWS is non-zero the interrupt service
*ought to be counting it down to zero. However, to avoid an
*infinite hold-up here, a check is made of the status of
*the CPU interrupt mask. Once the timer output compare flag
*has become set we can prepare the next delay.
*The delay value is 32 bits long, the high order word
*representing the number of complete cycles the counter must
*go through while the low order word is added to the previous
*target in the timer output compare register.
*If the addend is too small ( <128 ) the software may not be
*finished by the time the target is reached. This results in
*a time jump of 2^16 microseconds. If this is the case 128 is
*added and a correction flag is set. The flag is used in the
*interrupt service to subtract off the 128 when OVER-FLOWS
*reaches zero.
*If OVER-FLOWS is non-zero for this current delay the
*timer output compare interrupt is enabled.
*
0000 DC 84    DELAY  LDD OVFLWS Zero yet?
0002 27 05           BEQ DL3      If so don't wait
0004 07              TPA  Fetch CPU status bits
0005 85 10           BIT A #$10 Are interrupts masked?
0007 27 F7    DL2    BEQ DELAY If no then wait
0009 7B 40 08 DL3    TIM #$40 TIMCNT Test bit 6 of TIMCONT
000C 27 FB           BEQ DL3 Wait until flag is set
000E EC 02           LDD 2,X Get high order word
0010 08              INX     of delay
0011 08              INX
0012 DD 84           STD OVFLWS
0014 EC 02           LDD 2,X Get low order word
0016 08              INX     of delay
0017 08              INX
```

```
0018 7F 0091          CLR CORRFG+1 Reset correction flag
001B 4D               TST A High byte zero?
001C 26 08            BNE DL4 If not delay is at least
001E 5D               TST B   250 microseconds
001F 2B 05            BMI DL4 If low byte +ve. it

0021 CB 80            ADD B #128 is < 128 therefore + 128
0023 7C 0091          INC CORRFG and set correction flag
0026 D3 0B     DL4    ADD D TIMOCR Set up new
0028 DD 0B            STD TIMOCR   target value
002A DC 84            LDD OVFLWS
002C 27 06            BEQ DL5 If zero then skip
002E 96 08            LDA A TIMCNT
0030 8A 08            ORA A #8 Enable timer output
0032 97 08            STA A TIMCNT compare interrupt
0034 96 02     DL5    LDA A PORT1 Turn off ADC mute
0036 84 FB            AND A #$FB  that may have been
0038 97 02            STA A PORT1 left on by PING
003A 39               RTS
*
*
*PULSE
*-----
*
*PORT1 bits 0 and 1 drive the power amplifier through buffers;
*so to generate a push-pull drive one is initially turned-on
*and then they are toggled at intervals of 143 microseconds.
*During the pulse AGC is muted to prevent the receiver becoming
*deafened by the transmission. An additional time is allowed
*after the pulse when the signal is still decaying and the
*power amplifier reservoir capacitors are recharging. By
*adding 10 mSecs. to the timer target, saved at the start of
*PULSE, the total time taken for PULSE is independent of the
*actual pulse duration and any soft-ware jitter. But the pulse
*may not be much longer than 9 mSecs.
*
              HLFCYC EQU $82
              PNGSTR EQU $8C

0000 DC 0B    PULSE  LDD TIMOCR Save current target
0002 DD 8C           STD PNGSTR
0004 EC 02           LDD 2,X Get half cycle count
0006 08              INX     off stack
0007 08              INX
0008 D7 82           STA B HLFCYC
000A DC 84    PL1    LDD OVFLWS
000C 27 05           BEQ PL2 OVFLWS zero?
000E 07              TPA
000F 85 10           BIT A #$10 Are interrupts enabled?
0011 27 F7           BEQ PL1
0013 7B 40 08        TIM #$40 TIMCNT Wait until flag set
0016 27 FB           BEQ PL2
0018 96 02           LDA A PORT1 Turn on one power
001A 8A 01           ORA A #1    transistor
001C 97 02           STA A PORT1
001E 7B 40 08 PL3    TIM #$40 TIMCNT Wait until flag is set
0021 27 FB           BEQ PL3 1st time it is still set
0023 CC 008F         LDD #143 1/2 cycle of 3.5 kHz.
0026 D3 0B           ADD D TIMOCR Set up new target
0028 DD 0B           STD TIMOCR
```

```
002A 96 02          LDA A PORT1 Toggle power amplifier
002C 88 03          EOR A #3 to create push-pull drive
002E 8A 04          ORA A #4 Turn on AGC mute
0030 97 02          STA A PORT1
0032 7A 0082        DEC HLFCYC Pulse finished yet?
0035 26 E7          BNE PL3

0037 96 02          LDA A PORT1 Yes
0039 84 FC          AND A #$FC Turn off both transistors
003B 97 02          STA A PORT1
003D CC 2710        LDD #10000 Add 10 mSecs. to target
0040 D3 8C          ADD D PNGSTR as it was at start of
0042 DD 0B          STD TIMOCR   pulse
0044 39             RTS
*
*
*WAIT
*----
*
*Assuming a delay is running, the flag SIGFLG is set at the
*beginning of this routine. If a signal interrupt occurs before
*the delay finishes the routine exits as the interrupt clears
*SIGFLG. Otherwise an exit occurs at the end of the time delay
*with SIGFLG still set.
*
0000 CC 0001  WAIT   LDD #1 Set flag initially
0003 FD 0086         STD SIGFLG
0006 7D 0087  WT1    TST SIGFLG+1 Has it been cleared
0009 27 0F           BEQ WT3      by interrupt service?
000B FC 0084         LDD OVFLWS
000E 27 05           BEQ WT2
0010 07              TPA
0011 85 10           BIT A #$10
0013 27 F1           BEQ WT1
0015 7B 40 08 WT2    TIM #$40 TIMCNT Timer timed out?
0018 27 EC           BEQ WT1
001A 39       WT3    RTS
*
*
*DOWN?
*-----
*
*This procedure is called with an accelerometer value on the
*stack. Its purpose is to cause the water column sampling,
*PHASE1, to be aborted if either 10 samples of deceleration
*exceed a threshold or the optical switch interrupts and sets
*a flag MUDFLG. Should either happen a value is pushed onto the
*data stack to indicate which and the return stack pointer is
*incremented by 10. This alteration to the return stack throws
*away DOWN?'s return address and two sets of DO-LOOP control
*parametersto expose PHASE1's return address.
*
              DWNCNT EQU $88

0000 B6 1002  DOWN   LDA A ADCCNT Is optical switch interrupt
0003 85 10           BIT A #1     enable bit set?
0005 26 04           BNE DW1
0007 08              INX  No Drop value from
0008 08              INX  stack and return
0009 20 2C           BRA DW4
```

```
000B EC 02     DW1     LDD 2,X Remove value from stack
000D 08                INX
000E 08                INX
000F 7D 0080           TST MUDFLG Has optical switch
0012 26 13             BNE DW2 triggered and set MUDFLG?
0014 83 ****           LDD #THSHLD No. Is value greater
0017 2D 1E             BLT DW4      than threshold?

0019 7C 0088           INC DWNCNT  Yes
001C 96 88             LDA A DWNCNT Have 10 values
001E 81 0A             CMP A #10 exceeded threshold?
0020 2D 15             BLT DW4  If not return
0022 CC 0001           LDD #1 Yes  1=triggered by deceleration
0025 20 03             BRA DW3
0027 CC 0002   DW2     LDD #2      2=triggered by mud switch
002A ED 00     DW3     STD 0,X Push trigger code onto
002C 09                DEX     the stack
002D 09                DEX
002E C6 0A             LDA B #10
0030 DF F0             STX XTEMP Save data stack pointer
0032 30                TSX Copy return stack pointer into X
0033 3A                ABX add 10 to it
0034 35                TXS and put it back
0035 DE F0             LDX XTEMP Recover data stack pointer
0037 39                RTS
*
*
```

APPENDIX A3 PATSY INDEX

The following is a listing of the procedures that during compiling are appended to the FORTH vocabulary and constitute the user program. In order that the compiled code can be placed in ROM variables that would normally contain their own data space instead have a field that points to RAM elsewhere. The pointer DATA keeps track of the allocation of RAM space to variables.

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```
SCR # 3
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  1
  2
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  4
  5
  6
  7
  8
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 10
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 12
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 14
 15


SCR # 4
  0 ( ERROR MESSAGES )
  1 Empty stack
  2 Dictionary full
  3 Has incorrect address mode
  4 Isn't unique
  5
  6 Bubble memory range?
  7 Full stack
  8 Bubble memory error
  9
 10
 11
 12
 13
 14
 15 FORTH INTEREST GROUP
```

```
SCR # 5
  0 ( ERROR MESSAGES ...)
  1 Compilation only, use in definition
  2 Execution only
  3 Conditionals not paired
  4 Definition not finished
  5 In protected dictionary
  6 Use only when loading
  7 Off current editing screen
  8 Declare vocabulary
  9
 10
 11
 12
 13
 14
 15
```

FORTH INTEREST GROUP

```
SCR # 30
  0 ( CHECKSUMS, ?B, U., CODE, DATA, RTI )
  1 : PATSY ; HEX
  2 : CHECKSUMS HEX 0 1 CR BEGIN 2000 0 DO DUP I E000 + AND
  3     IF SWAP I E000 + C@ + SWAP
  4     THEN LOOP DUP 0 D. SWAP 0 D. 0 SWAP CR DUP + DUP 0=
  5     UNTIL DROP DROP ;
  6 : BINARY 2 BASE ! ;
  7 : OCTAL 8 BASE ! ;
  8 : ?B BASE @ DUP DECIMAL . BASE ! ;
  9 : U. 0 D. ;
 10 : CODE ?EXEC !CSP CURRENT @ CONTEXT ! CREATE HEX ;
 11 0 USER DATA 4800 DATA !
 12 : RETURN ?CSP 39 C, SMUDGE ;
 13 : RTI ?CSP 3B C, SMUDGE [COMPILE] [ ; IMMEDIATE
 14
 15 -->


SCR # 31
  0 ( CASE )
  1 : CASE     ?COMP CSP @ !CSP 4 ; IMMEDIATE
  2 : OF       4 ?PAIRS COMPILE OVER COMPILE =
  3            [COMPILE] IF 5 ; IMMEDIATE
  4 : ENDOF    5 ?PAIRS [COMPILE] ELSE 4 ; IMMEDIATE
  5
  6 : ENDCASE 4 ?PAIRS
  7           BEGIN SP@ CSP @ = 0=
  8           WHILE 2 [COMPILE] THEN
  9           REPEAT CSP ! COMPILE DROP ; IMMEDIATE
 10
 11
 12
 13
 14
 15 -->


SCR # 32
  0 ( CONSTANTS )
  1 HEX 1000 CONSTANT ADCDAT 1002 CONSTANT ADCCONT
  2 0 CONSTANT PORT1DIR 2 CONSTANT PORT1
  3 8 CONSTANT TIMCONT 9 CONSTANT COUNTER
  4 B CONSTANT TIMOCR D CONSTANT TIMICR
  5 80 CONSTANT MUDFLAG 82 CONSTANT HLFCYC
  6 84 CONSTANT OVER-FLOWS 86 CONSTANT SIGFLAG
  7 88 CONSTANT DOWN-COUNT 8A CONSTANT CYCLES
  8 8C CONSTANT PNGSTR 8E CONSTANT TIME-ERROR
  9 266 CONSTANT THRESHOLD 90 CONSTANT CORRFG
 10
 11
 12
 13
 14
 15 -->
```

```
SCR # 33
  0 ( DECLARING WORDS )
  1 : VAR <BUILDS DATA @ DUP , ! 2 DATA +! DOES> @ ;
  2 : ROLLING-BUFFER <BUILDS 2 * DATA @ DUP , DUP 2+
  3    SWAP ! DATA @ + DUP , 2+ DATA ! ;CODE
  4    DFFO , 383C , EE03 , EC00 , DDE0 , C3 C, 2 ,
  5    ED00 , 38 C, A305 , 2309 , EC03 , EE03 , C3 C,
  6    2 , ED00 , DEF0 , DCE0 , ED00 , 0909 , RETURN
  7 : ARRAY+ <BUILDS 2 * DATA @ DUP , DUP 2+ SWAP !
  8    DATA @ + DUP , 2+ DATA ! ;CODE
  9    DFFO , 383C , EE03 , EC00 , DDE0 , C3 C, 2 ,
 10    ED00 , 38 C, A305 , 2306 , EC05 , EE03 , ED00 ,
 11    DEF0 , DCE0 , ED00 , 0909 , RETURN
 12 : ARRAY <BUILDS 2 * DATA @ , DATA +! DOES> @ ;
 13 : CHANNEL-TABLE <BUILDS DATA @ DUP , 30 ERASE
 14    30 DATA +! DOES> @ ;
 15 -->


SCR # 34
  0 ( UTILITIES )
  1 : I/O-INIT 0 PORT1 C! 4F PORT1DIR C! 0 PORT1 C!
  2    0 ADCCONT ! F000 ADCDAT ! 3C2C ADCCONT ! ;
  3 : SUPPLIES-ON PORT1 C@ 8 OR PORT1 C! ;
  4 : SUPPLIES-OFF PORT1 C@ F7 AND PORT1 C! ;
  5 CODE ENABLE-INTERRUPTS E C, RETURN
  6 CODE DISABLE-INTERRUPTS F C, RETURN
  7 : ENABLE-OPTICAL-SWITCH ADCCONT C@ DROP ADCDAT C@ DROP
  8    ADCCONT DUP C@ 1 OR SWAP C! ;
  9 : DISABLE-OPTICAL-SWITCH ADCCONT DUP C@ 3E AND SWAP C!
 10 : DISABLE-SIGNAL TIMCONT DUP DUP C@ SWAP 5 + C@ DROP
 11    EF AND SWAP C! ;
 12 : ENABLE-SIGNAL TIMCONT DUP DUP C@ SWAP 5 + C@ DROP
 13    10 OR SWAP C! ;
 14 : MSEC. 03E8 U* ;
 15 -->


SCR # 35
  0 ( INTERRUPT SERVICE ROUTINES )
  1
  2    ( TIMER )
  3 CODE TISR DC C, TIMCONT C, DE C, OVER-FLOWS C, 2705 , 09 C,
  4    DF C, OVER-FLOWS C, 2612 , 96 C, TIMCONT C, 84F7 , 97 C,
  5    TIMCONT C, 7D C, CORRFG 1+ , 2707 , DC C, TIMOCR C, 83 C,
  6    80 , 2002 , DC C, TIMOCR C, DD C, TIMOCR C, RTI
  7
  8    ( SIGNAL )
  9 CODE SISR 96 C, TIMCONT C, D6 C, TIMICR C, 84EF , 97 C,
 10    TIMCONT C, 4F5F , DD C, SIGFLAG C, RTI
 11
 12    ( MUD SENSOR )
 13 CODE MSISR B6 C, ADCCONT , 2B04 , B6 C, ADCDAT , 2007 ,
 14   B6 C, ADCDAT , 86FF , 97 C, MUDFLAG C, RTI
 15 -->

FORTH INTEREST GROUP
```

```
SCR # 36
  0 ( DUMMY INTERRUPTS SERVICES, LINK, GETSET )
  1 CODE SERIAL 9611 , 85EB , 9711 , RTI
  2
  3 CODE TIMER-O'FLOW DC08 , 84FB , 9708 , RTI
  4
  5 : LINK 3 * D0 + DUP 7E SWAP C! 1+ ! ;
  6
  7
  8
  9 : GETSET I/O-INIT 0 OVER-FLOWS ! 0 MUDFLAG ! 0 SIGFLAG !
 10   0 DOWN-COUNT ! ENABLE-INTERRUPTS SUPPLIES-ON ;
 11
 12
 13
 14
 15 -->

SCR # 37
  0 ( VARIABLES, ARRAYS )
  1 CHANNEL-TABLE TABLE1 CHANNEL-TABLE TABLE2
  2 CHANNEL-TABLE TABLE3 ' TABLE1 6 + VAR TABLE
  3 DECIMAL
  4 0 VAR NO.1 0 VAR NO.2 0 VAR NO.3 0 VAR NO.4
  5 0 VAR NO.5 0 VAR NO.6 0 VAR NO.7 0 VAR NO.8 0 VAR NO.9
  6 0 VAR ACELN1LIVE 0 VAR ACELN2LIVE 0 VAR TILT1LIVE
  7 0 VAR TILT2LIVE 0 VAR TEMPLIVE 0 VAR BACKBY
  8 1250 ARRAY+ ACELN1FAST 1250 ARRAY+ ACELN2FAST
  9 10 ARRAY PING-LIST 0 VAR SIGNAL
 10 1600 ARRAY+ ACELN1 1600 ARRAY+ ACELN2
 11 1600 ARRAY+ TILT1 1600 ARRAY+ TILT2
 12 1600 ARRAY+ TEMP
 13 4000 ROLLING-BUFFER ACELNRB1 4000 ROLLING-BUFFER ACELNRB2
 14 ." Next free RAM location would be " HEX DATA @ U.
 15 DECIMAL -->

SCR # 38
  0 ( CURRENT-TABLE, TABLE?, READ-TABLE )
  1 : CURRENT-TABLE CASE
  2     1 OF ' TABLE1 6 + TABLE ! ENDOF
  3     2 OF ' TABLE2 6 + TABLE ! ENDOF
  4     3 OF ' TABLE3 6 + TABLE ! ENDOF
  5     ENDCASE ;
  6 : TABLE? TABLE @ CASE
  7     ' TABLE1 6 + OF ." TABLE 1" ENDOF
  8     ' TABLE2 6 + OF ." TABLE 2" ENDOF
  9     ' TABLE3 6 + OF ." TABLE 3" ENDOF ENDCASE ;
 10 : READ-TABLE CR TABLE? TABLE @ @ CR
 11 ."              CHAN.    F.S.(MSEC.) F.S.(VALUE) OFFSET(MSEC.) " CR
 12 8 0 DO I 0 12 D.R DUP I 6 * + @ S->D 12 D.R
 13                   DUP I 6 * + 2+ @ S->D 12 D.R
 14                   DUP I 6 * + 4 + @ S->D 12 D.R
 15 CR LOOP DROP ; -->

FORTH INTEREST GROUP
```

```
SCR # 39
  0 ( TABLE-ENTRY, READ-LIST, SCALE, SORT )
  1 : TABLE-ENTRY >R ROT R> SWAP TABLE @ @ SWAP 8 MOD DUP 0<
  2    IF 8 +
  3    THEN 6 * + 4 + DUP >R ! R 2 - ! R> 4 - ! READ-TABLE ;
  4 : READ-LIST 22 2 DO PING-LIST I + @ . 2 +LOOP ;
  5
  6 : SCALE 6 * TABLE @ @ + DUP @ 0=
  7    IF DROP DROP 0
  8    ELSE DUP >R DUP @ SWAP 2+ @ */ R @ MOD R> 4 + @ +
  9    THEN ;
 10
 11 CODE SORT 3C C, 8601 , 36 C, CE C, PING-LIST 2+ , EC00 , A302 ,
 12    2F13 , A600 , E602 , A702 , E700 , A601 , E603 , A703 ,
 13    E701 , 32 C, 4F C, 36 C, 0808 , 8C C, PING-LIST 10 + ,
 14    26E0 , 32 C, 4D C, 27D6 , 38 C, RETURN
 15 -->


SCR # 40
  0 ( CHECK, RELATIVES )
  1 CODE CHECK 3C C, CE C, PING-LIST , 4F5F , ED12 , ED14 , 8608 ,
  2    36 C, CE C, PING-LIST , EC02 , 83 C, 14 , 2A10 , EC04 ,
  3    ED02 , 0808 , 8C C, PING-LIST 10 + , 26F5 , 32 C, 4A C, 36 C,
  4    26E6 , 32 C, CE C, PING-LIST , EC02 , 2607 , CC C, 762 ,
  5    ED02 , 2011 , 83 C, 74E , 2505 , CC C, 74E , ED02 , 0808 ,
  6    8C C, PING-LIST 12 + , 26E4 , CE C, PING-LIST , EC04 , 271F ,
  7    A302 , 83 C, 13 , 2A11 , 3C C, EC04 , ED02 , 2707 , 0808 ,
  8    8C C, PING-LIST 12 + , 26F3 , 38 C, 20E4 , 0808 , 8C C,
  9   PING-LIST 10 + , 26DD , 38 C, RETURN
 10 : RELATIVES 0 10 DO PING-LIST I + 2+ @ DUP
 11    IF PING-LIST I + @ - A - PING-LIST I + 2+ !
 12    ELSE DROP
 13    ENDIF -2 +LOOP ;
 14
 15 DECIMAL -->


SCR # 41
  0 ( LIST1 )
  1 : LIST1 SIGNAL @ 0 SCALE PING-LIST 2+ !
  2         ACELN1FAST @ 1 SCALE PING-LIST 4 + !
  3         ACELN2FAST @ 2 SCALE PING-LIST 6 + !
  4         0 PING-LIST 8 + !
  5         0 PING-LIST 10 + !
  6         0 PING-LIST 12 + !
  7         0 PING-LIST 14 + !
  8         0 PING-LIST 16 + ! ;
  9
 10
 11
 12
 13
 14
 15 DECIMAL -->
```

FORTH INTEREST GROUP

```
SCR # 42
  0 ( LIST2 )
  1 : LIST2 SIGNAL @ 0 SCALE PING-LIST 2+ !
  2         ACELN1 @ 1 SCALE PING-LIST 4 + !
  3         ACELN2 @ 2 SCALE PING-LIST 6 + !
  4         TILT1  @ 3 SCALE PING-LIST 8 + !
  5         TILT2  @ 4 SCALE PING-LIST 10 + !
  6         TEMP   @ 6 SCALE PING-LIST 12 + !
  7         0 PING-LIST 14 + !.
  8         0 PING-LIST 16 + ! ;
  9
 10
 11
 12
 13
 14
 15 -->


SCR # 43
  0 ( LIST3 )
  1 : LIST3 SIGNAL     @ 0 SCALE PING-LIST 2+ !
  2         ACELN1LIVE @ 1 SCALE PING-LIST 4 + !
  3         ACELN2LIVE @ 2 SCALE PING-LIST 6 + !
  4         TILT1LIVE  @ 3 SCALE PING-LIST 8 + !
  5         TILT2LIVE  @ 4 SCALE PING-LIST 10 + !
  6        TEMPLIVE   @ 6 SCALE PING-LIST 12 + !
  7         0 PING-LIST 14 + !
  8         0 PING-LIST 16 + ! ;
  9
 10
 11
 12
 13
 14
 15 -->


SCR # 44
  0 ( SAMPLE, DELAY )
  1 CODE SAMPLE EC02 , 5858 , 5858 , F7 C, ADCDAT , B6 C,
  2    ADCCONT , 8437 , B7 C, ADCCONT , 7C C, ADCDAT 1+ ,
  3    7D C, ADCCONT 1+ , 2AFB , B6 C, ADCCONT , 8A08 ,
  4    B7 C, ADCCONT , FC C, ADCDAT , 840F , 83 C, 800 ,
  5    4350 , 2601 , 4C C, ED02 , RETURN
  6
  7 CODE DELAY DC C, OVER-FLOWS C, 2705 , 07 C, 8510 , 27F7 ,
  8    7B40 , TIMCONT C, 27FB , EC02 , 0808 , DD C, OVER-FLOWS C,
  9    EC02 , 0808 , 7F C, CORRFG 1+ , 4D C, 2608 , 5D C, 2B05 ,
 10    CB80 , 7C C, CORRFG 1+ , D3 C, TIMOCR C, DD C, TIMOCR C,
 11    DC C, OVER-FLOWS C, 2706 , 96 C, TIMCONT C, 8A08 , 97 C,
 12    TIMCONT C, 96 C, PORT1 C, 84FB , 97 C, PORT1 C, RETURN
 13
 14
 15 -->

FORTH INTEREST GROUP
```

```
SCR # 45
  0 ( PULSE, WAIT, DOWN? )
  1 CODE PULSE DC0B , DD8C , EC02 , 0808 , D782 , DC84 ,
  2   2705 , 07 C, 8510 , 27F7 , 7B40 , TIMCONT C, 27FB ,
  3   96 C, PORT1 C, 8A01 , 97 C, PORT1 C, 7B40 , TIMCONT C,
  4   27FB , CC C, 8F , D3 C, TIMOCR C, DD C, TIMOCR C, 96 C,
  5   PORT1 C, 8803 , 8A04 , 97 C, PORT1 C, 7A C, HLFCYC ,
  6   26E7 , 96 C, PORT1 C, 84FC , 97 C, PORT1 C, CC C,
  7    2710 , D3 C, PNGSTR C, DD C, TIMOCR C, RETURN
  8 CODE WAIT CC C, 1 , FD C, SIGFLAG , 7D C, SIGFLAG 1+ ,
  9   270F , FC C, OVER-FLOWS , 2705 , 07 C, 8510 ,
 10    27F1 , 7B40 , TIMCONT C, 27EC , RETURN
 11 CODE DOWN? B6 C, ADCCONT , 8501 , 2604 , 0808 , 202C ,
 12    EC02 , 0808 , 7D C, MUDFLAG , 2613 , 83 C, THRESHOLD ,
 13    2D1E , 7C C, DOWN-COUNT , 96 C, DOWN-COUNT C, 810A ,
 14    2D15 , CC C, 1 , 2003 , CC C, 2 , ED00 , 0909 , C60A ,
 15    DFF0 , 30 C, 3A35 , DEF0 , RETURN DECIMAL -->


SCR # 46
  0 ( PREPARE1/2/3, P15?, PING, WATER?, TRANSMIT, SYNC. )
  1 : PREPARE1 LIST1 SORT CHECK RELATIVES ;
  2 : PREPARE2 LIST2 SORT CHECK RELATIVES ;
  3 : PREPARE3 LIST3 SORT CHECK RELATIVES ;
  4 : P15? PORT1 C@ 32 AND ;
  5 : PING 35 PULSE ;
  6 : WATER? BEGIN PING 100 0 DO 100 MSEC. DELAY
  7    P15? IF LEAVE THEN LOOP P15? UNTIL ;
  8 : TRANSMIT 18 0 DO PING-LIST 2+ I + @ -DUP
  9       IF PING MSEC. DELAY
 10      ELSE LEAVE ENDIF 2 +LOOP ;
 11 : SYNC. TIMICR @ 10000 + TIMCONT C@ 247 AND TIMCONT C!
 12    TIMOCR ! 0 OVER-FLOWS ! 0 10 0 DO 0 SAMPLE DUP
 13    SIGNAL ! OVER > IF DROP SIGNAL @
 14    ELSE COUNTER @ 8600 + TIMOCR ! LEAVE THEN LOOP ;
 15 -->


SCR # 47
  0 ( RESET, BACKUP )
  1 : RESET 6 + @ DUP 2+ SWAP ! ;
  2 : BACKUP 2 * SWAP 6 + DUP >R @ @ SWAP - DUP R @ - DUP 0 >
  3    IF DROP
  4    ELSE SWAP DROP R 2+ @ +
  5    ENDIF R> @ ! ;
  6 : TRANSFER ' ACELN1FAST RESET ' ACELN2FAST RESET
  7    ' ACELNRB1 BACKBY @ BACKUP ' ACELNRB2 BACKBY @ BACKUP
  8    1250 0 DO ACELNRB1 @ ACELN1FAST !
  9             ACELNRB2 @ ACELN2FAST ! LOOP
 10    ' ACELN1FAST RESET ' ACELN2FAST RESET ;
 11 : CLEAR ' ACELN1 RESET ' ACELN2 RESET ' TILT1 RESET
 12    ' TILT2 RESET ' TEMP RESET ;
 13
 14
 15 -->

FORTH INTEREST GROUP
```

```
SCR # 48
  0 ( PHASE1A )
  1 DECIMAL
  2 : PHASE1A 600 0 DO
  3     50 MSEC. DELAY
  4     1 SAMPLE ACELN1 !
  5     2 SAMPLE ACELN2 !
  6     3 SAMPLE TILT1 !
  7     4 SAMPLE TILT2 !
  8     6 SAMPLE TEMP !
  9     50 MSEC. DELAY
 10                        LOOP
 11     ENABLE-OPTICAL-SWITCH ;
 12
 13
 14
 15 -->


SCR # 49
  0 ( PHASE1B )
  1 DECIMAL
  2 : PHASE1B 0 DO
  3     24 0 DO 2 MSEC. DELAY 1 SAMPLE DUP ACELNRB1 ! DOWN?
  4                             2 SAMPLE DUP ACELNRB2 ! DOWN?
  5                                                   LOOP
  6       4 MSEC. DELAY 1 SAMPLE DUP ACELN1 ! ACELNRB1 !
  7                     2 SAMPLE DUP ACELN2 ! ACELNRB2 !
  8                     3 SAMPLE TILT1 !
  9                     4 SAMPLE TILT2 !
 10     1 SAMPLE ACELNRB1 ! 2 SAMPLE ACELNRB2 ! 6 SAMPLE TEMP !
 11     24 0 DO 2 MSEC. DELAY 1 SAMPLE DUP ACELNRB1 ! DOWN?
 12                             2 SAMPLE DUP ACELNRB2 ! DOWN?
 13     LOOP LOOP 0 ;
 14
 15 -->


SCR # 50
  0 ( PHASE2 )
  1
  2 : PHASE2 0 DO
  3     48 0 DO 2 MSEC. DELAY 1 SAMPLE ACELNRB1 !
  4                             2 SAMPLE ACELNRB2 !
  5                                               LOOP
  6     4 MSEC. DELAY 1 SAMPLE DUP ACELN1 ! ACELNRB1 !
  7                   2 SAMPLE DUP ACELN2 ! ACELNRB2 !
  8                   3 SAMPLE TILT1 !
  9                   4 SAMPLE TILT2 !
 10                   1 SAMPLE ACELNRB1 !
 11                   2 SAMPLE ACELNRB2 !
 12                   6 SAMPLE TEMP !          LOOP
 13     DISABLE-OPTICAL-SWITCH ;
 14
 15 -->

FORTH INTEREST GROUP
```

```
SCR # 51
  0 ( SAMPLE-NOW, MARK )
  1 : SAMPLE-NOW 0 SIGNAL !
  2    1 SAMPLE ACELN1LIVE ! 2 SAMPLE ACELN2LIVE !
  3    3 SAMPLE TILT1LIVE  ! 4 SAMPLE TILT2LIVE !
  4    6 SAMPLE TEMPLIVE ! ;
  5
  6 : MARK 2 = IF ' ACELNRB1 1000 BACKUP ' ACELNRB2 1000 BACKUP
  7    5 0 DO 51 ACELNRB1 +! LOOP
  8    ' ACELNRB1 5 BACKUP 250 BACKBY.!
  9    ELSE 1250 BACKBY ! THEN ;
 10
 11 : PREPARE4 SIGNAL @ DUP 0<
 12    IF 0 ELSE 8 / THEN 20 + PING-LIST 2+ !
 13    22 4 DO 0 PING-LIST I + ! 2 +LOOP
 14    SORT CHECK RELATIVES ;
 15 -->


SCR # 52
  0 ( DATA TRANSMISSION BY PINGING )
  1 : FAST-DATA-PINGING ' ACELN1FAST RESET ' ACELN2FAST RESET
  2    PREPARE1 0 DO TRANSMIT TIME-ERROR @ 34464 + 1
  3    DELAY PREPARE1 LOOP ;
  4
  5 : MEDIUM-DATA-PINGING CLEAR PREPARE2 0 DO
  6    TRANSMIT TIME-ERROR @ 34464 + 1 DELAY PREPARE2
  7    LOOP ;
  8
  9 : LIVE-PINGING SAMPLE-NOW PREPARE3 0 DO
 10    TRANSMIT TIME-ERROR @ 34464 + 1 DELAY SAMPLE-NOW
 11    PREPARE3 LOOP ;
 12
 13 : READY? BEGIN PING 0 600 0 DO DROP 0 300 0 DO DROP
 14    100 MSEC. DELAY P15? IF 0 LEAVE ELSE 1 THEN LOOP
 15    IF 1 LEAVE ELSE 0 THEN LOOP UNTIL ;    -->


SCR # 53
  0 ( TRANSPOND )
  1 : TRANSPOND PREPARE4 0 1 ROT ROT DO 0=
  2    IF SYNC. TRANSMIT PREPARE4 80 MSEC. DELAY 20 MSEC.
  3    ELSE 10 MSEC. DELAY DISABLE-SIGNAL PING 980 MSEC.
  4    DELAY 1000 MSEC.
  5    THEN DELAY ENABLE-SIGNAL WAIT SIGFLAG @
  6    LOOP DROP ;
  7
  8 : SKIPLINE 2000 MSEC. DELAY ;
  9
 10 : ANNOUNCE 5 0 DO PING 90 MSEC. DELAY LOOP ;
 11
 12
 13
 14
 15 -->
```

FORTH INTEREST GROUP

```
SCR # 54
  0 ( PARAMETERS )
  1 HERE 0 , 0 , 0 , 2000 , 2048 , 100 , 2000 , 2048 , 200 ,
  2 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0 , 0 ,
  3 0 , 0 , 0 , 2000 , 2048 , 100 , 2000 , 2048 , 200 ,
  4 900 , 614 , 1000 , 900 , 614 , 1100 , 0 , 0 , 0 ,
  5 750 , 1229 , 1250 , 0 , 0 , 0 ,
  6 0 , 0 , 0 , 2000 , 2048 , 100 , 2000 , 2048 , 200 ,
  7 900 , 614 , 1000 , 900 , 614 , 1100 , 0 , 0 , 0 ,
  8 750 , 1229 , 1250 , 0 , 0 , 0 ,
  9 360 , 32000 , 20 , 150 , 150 , 1250 , 1600 , 900 , 150 , 1250 ,
 10 CONSTANT PARAMETERS
 11
 12
 13
 14
 15 -->


SCR # 55
  0 ( FILL-TABLE, SETUP )
  1 : FILL-TABLE DO PARAMETERS I 2 * + @ TABLE @ @ I 24
  2    MOD 2 * + ! LOOP ;
  3 : SETUP 18432 DUP 56000 SWAP - ERASE
  4    1 CURRENT-TABLE 24 0 FILL-TABLE READ-TABLE
  5    2 CURRENT-TABLE 48 24 FILL-TABLE READ-TABLE
  6    3 CURRENT-TABLE 72 48 FILL-TABLE READ-TABLE
  7 CR PARAMETERS 144 + DUP @ ." TIME-ERROR = " DUP . TIME-ERROR !
  8 CR 2 + DUP @ ." NO.1 = " DUP U. NO.1 ! CR 2 + DUP @
  9 ." NO.2 = " DUP . NO.2 ! CR 2 + DUP @ ." NO.3 = " DUP . NO.3 !
 10 CR 2 + DUP @ ." NO.4 = " DUP . NO.4 ! CR 2 + DUP @
 11 ." NO.5 = " DUP . NO.5 ! CR 2 + DUP @ ." NO.6 = " DUP .
 12 NO.6 ! CR  2 + DUP @ ." NO.7 = " DUP . NO.7 ! CR 2 + DUP @
 13 ." NO.8 = " DUP . NO.8 ! CR 2 + @ ." NO.9 = " DUP . NO.9 !
 14 CR GETSET ;
 15 -->


SCR # 56
  0 ( JRC )
  1 : JRC ' ACELN1FAST RESET 0 DO PING 40 MSEC. DELAY
  2    PING 90 MSEC. DELAY PING 190 MSEC. DELAY
  3    PING 240 MSEC. DELAY
  4    ACELN1FAST @ DUP 63 AND 10 * DUP 1+ MSEC. DELAY PING
  5    679 SWAP - MSEC. DELAY
  6    4032 AND 10 64 */ DUP 1+ MSEC. DELAY PING
  7    679 SWAP - MSEC. DELAY 20000 TIME-ERROR @ + 0 DELAY
  8    LOOP ;
  9
 10
 11
 12
 13
 14
 15 -->

FORTH INTEREST GROUP
```

```
SCR # 57
  0 ( MARION DUFRESNE )
  1 : TRIAL1 ' SERIAL 0 LINK ' TIMER-O'FLOW 1 LINK
  2     ' TISR 2 LINK ' SISR 3 LINK ' MSISR 4 LINK
  3     DISABLE-OPTICAL-SWITCH READY? WATER? ANNOUNCE
  4     CLEAR ' ACELNRB1 RESET ' ACELNRB2 RESET
  5     PHASE1A NO.1 @ PHASE1B
  6     NO.2 @ PHASE2 MARK TRANSFER 3 CURRENT-TABLE
  7     NO.3 @ LIVE-PINGING
  8     NO.4 @ TRANSPOND  SKIPLINE
  9     BEGIN                        1 CURRENT-TABLE
 10     NO.5 @ FAST-DATA-PINGING SKIPLINE 2 CURRENT-TABLE
 11     NO.6 @ MEDIUM-DATA-PINGING SKIPLINE
 12     NO.7 @ TRANSPOND SKIPLINE
 13     NO.8 @ LIVE-PINGING SKIPLINE
 14     NO.9 @ JRC SKIPLINE
 15     AGAIN ;


SCR # 58
  0
  1
  2
  3
  4
  5
  6
  7
  8
  9
 10
 11
 12
 13
 14
 15


SCR # 59
  0
  1
  2
  3
  4
  5
  6
  7
  8
  9
 10
 11
 12
 13
 14
 15
```

FORTH INTEREST GROUP

VOCABULARY

PATSY

TRIAL1 JRC SETUP FILL-TABLE* PARAMETERS SKIPLINE TRANSPOND
READY? LIVE-PINGING MEDIUM-DATA-PINGING FAST-DATA-PINGING PREPARE4
MARK SAMPLE-NOW PHASE2 PHASE1B PHASE1A CLEAR TRANSFER BACKUP
RESET SYNC. TRANSMIT WATER? PING P15? PREPARE3 PREPARE2
PREPARE1 DOWN? WAIT PULSE DELAY SAMPLE LIST3 LIST2 LIST1
RELATIVES CHECK SORT SCALE READ-LIST TABLE-ENTRY READ-TABLE
TABLE? CURRENT-TABLE ACELNRB2 ACELNRB1 TEMP TILT2 TILT1
ACELN2 ACELN1 SIGNAL PING-LIST ACELN2FAST ACELN1FAST BACKBY
TEMPLIVE TILT2LIVE TILT1LIVE ACELN2LIVE ACELN1LIVE NO.9 NO.8
NO.7 NO.6 NO.5 NO.4 NO.3 NO.2 NO.1 TABLE TABLE3 TABLE2
TABLE1 GETSET LINK TIMER-O'FLOW SERIAL MSISR SISR TISR
MSEC. ENABLE-SIGNAL DISABLE-SIGNAL DISABLE-OPTICAL-SWITCH ENABLE-OPTICAL
-SWITCH
DISABLE-INTERRUPTS ENABLE-INTERRUPTS SUPPLIES-OFF SUPPLIES-ON
I/O-INIT CHANNEL-TABLE ARRAY ARRAY+ ROLLING-BUFFER VAR CORRFG
THRESHOLD TIME-ERROR PNGSTR CYCLES DOWN-COUNT SIGFLAG OVER-FLOWS
HLFCYC MUDFLAG TIMICR TIMOCR COUNTER TIMCONT PORT1 PORT1DIR
ADCCONT ADCDAT ENDCASE ENDOF OF CASE RTI RETURN DATA
CODE U. ?B OCTAL BINARY CHECKSUMS PATSY TASK FORTH
NOOP LINK MON P. WHERE EDITOR LINE TEXT C/L M/ M*
+- D+- VLIST TRIAD INDEX LIST ? . D. D.R .R #S
SIGN #> <# SPACES WHILE ELSE IF REPEAT AGAIN END
UNTIL +LOOP LOOP DO THEN ENDIF BEGIN BACK FORGET
R/W DRIVE DRB --> LOAD MESSAGE .LINE (LINE) BLOCK BUFFER
DR1 DR0 EMPTY-BUFFERS UPDATE +BUF PREV USE DABS ABS
M/MOD */ */MOD MOD / /MOD * S->D COLD ABORT QUIT
(DEFINITIONS VOCABULARY IMMEDIATE INTERPRET DLITERAL LITERAL
[COMPILE] CREATE ID. ERROR (ABORT) -FIND NUMBER (NUMBER)
WORD PAD HOLD BLANKS ERASE FILL QUERY EXPECT ?STACK
." (.") -TRAILING TYPE COUNT DOES> <BUILDS ;CODE (;CODE)
DECIMAL HEX SMUDGE] [COMPILE ?LOADING ?CSP ?PAIRS
?EXEC ?COMP ?ERROR !CSP PFA NFA LFA LATEST TRAVERSE
-DUP MAX MIN SPACE ROT > < = - C, , ALLOT HERE
2+ 1+ COLUMNS HLD R# CSP FLD DPL BASE STATE CURRENT
CONTEXT OFFSET SCR OUT IN BLK VOC-LINK DP FENCE WARNING
WIDTH TIB R0 S0 +ORIGIN B/SCR B/BUF LIMIT FIRST BL
3 2 1 0 USER VARIABLE CONSTANT ; : C! ! C@ @
TOGGLE +! DUP SWAP DROP OVER DMINUS MINUS D+ + 0<
0= R R> >R LEAVE ;S RP! SP! SP@ XOR OR AND U/
U* CMOVE CR ?TERMINAL KEY EMIT ENCLOSE (FIND) DIGIT
I (DO) (+LOOP) (LOOP) OBRANCH EXECUTE CLITER LIT

EDITOR

C B. DELETE COPY FLUSH CLEAR TOP I P R L T M
D S E H -MOVE #LAG #LEAD #LOCATE TASK FORTH NOOP
LINK MON P. WHERE EDITOR LINE TEXT C/L M/ M* +-
D+- VLIST TRIAD INDEX LIST ? . D. D.R .R #S #
SIGN

APPENDIX A4 PATSY GLOSSARY

A.4 PATSY GLOSSARY

Many words in FORTH receive parameters from a data stack and may return some. The notation used here is :-

```
S:L   < WORD >
          n1 n2 --- n3
          ( Description of the function of the word )
```

n1 and n2 are 16 bit values on the stack before execution, the right-most being at the top of the stack.
--- denotes the function being performed and
n3 a value returned to the stack. eg.

```
13:9 +            n1  n2  ---  sum
          Return to the stack the sum n1+n2
```

S and L are respectively the screen and line numbers of the word in the index.

Other words created during compiling can later be executed to assist the compiler to build a control structure like CASE or to create new classes of word such as data types with a user defined format and run-time behaviour. The notation used is :-

```
12:11 < STRING >
          n   < WORD >    < STRING >
```

This creates a new FORTH word of name < STRING > and class < WORD > using a parameter n. eg.

```
37:9  PING-LIST
          10 ARRAY PING-LIST
```

Creates a one dimensional array of 10 elements called PING-LIST with a call to the run-time code provided by the word ARRAY

Not all the words in the index are defined in the glossary as some are redundant and others speak for themselves.

30:1 PATSY
A dummy word to mark the start of the extension to the FORTH dictionary.

30.10 CODE
CODE < string > .....RETURN
Creates a machine code word of name < string > and sets the number base to hexidecimal. Double or single bytes may then be stored into the word using "," and "c,".

30:11 DATA
A FORTH variable containing a pointer to variable space in RAM. It is inially1ised to 4800 hex.

30:12 RETURN
Completes a code definition.

30:13 RTI
Completes either a high level or code word that is an interrupt service routine.

31:1 CASE,OF,ENDOF,ENDCASE
These words build a CASE structure when used during compiling. The form created will be :-
CASE value OF ... ENDOF
value OF ... ENDOF etc.
... ENDCASE
The words between OF and ENDOF are executed if the number on the stack at run-time is equal to value otherwise words preceding ENDCASE are executed.

33:1 VAR
n VAR < string >
Creates a variable of name < string > that points to a 16 bit location in RAM initialised to n. When < string > is executed the address of that RAM location is pushed onto the stack.

33:2 ROLLING-BUFFER
n ROLLING-BUFFER < string >
Creates a one dimensional array, < string >, of n elements. Each time an array of this type is executed the address of the next element is returned until the end of the array is passed when the address of the first element is pushed onto the stack.

33:7 ARRAY+
n ARRAY+ < string >
Creates an array like ROLLING-BUFFER except that when the last element is reached this one's address is repeated for any further calls. ie the array saturates.

33:12 ARRAY
n ARRAY < string >
Creates a one dimensional array of name < string > which at run-time returns the address of the first element (less 2 for technical reasons).

33:13 CHANNEL-TABLE
CHANNEL-TABLE < string >
Builds an 8 by 3 array to hold scaling parameters for 8 data channels.

34:1 I/O-INIT

This word initialises the CPU 8 bit port by defining which lines are to be inputs or outputs and then programs the 16 bit parallel port that interfaces to the analogue to digital converter.

34:3 SUPPLIES-ON
34:4 SUPPLIES-OFF
These words control the supplies for external sensors.

34:5 ENABLE-INTERRUPTS
34:6 DISABLE-INTERRUPTS
All interrupts to the CPU can be masked or unmasked by these words.

34:7 ENABLE-OPTICAL-SWITCH
34:9 DISABLE-OPTICAL-SWITCH
These words control interrupts from the optical switch. The state of the switch can also be sensed via bit 5 of the CPU port PORT1.

34:10 DISABLE-SIGNAL
34:12 ENABLE-SIGNAL
Interrupts from the receiver during transponding can be inhibited or enabled by these words.

34:14 MSEC.
n --- ud
Multiplies the single precision number n by 1000 to generate an unsigned double precision number ud. If n is in mSec. then ud is in micro-seconds. eg.
10 MSEC. DELAY

35:3 TISR (Timer Interrupt Service Routine)
For delays longer than 2^16 micro-seconds the number of complete cycles of the counter is stored in OVER-FLOWS. This interrupt service decrements OVER-FLOWS on successive interrupts and on reaching zero it disables itself.
See notes for details of timer operation.

35:9 SISR (Signal Interrupt Service Routine)
When a receiver interrupt occurs this routine clears a flag SIGFLAG and disables itself. SIGFLAG is sensed during transponding.

35:12 MSISR (Mud Sensor Interrupt Service Routine)
If the optical switch makes a transition when enabled to interrupt this routine checks that this is the source of the interrupt and if it is sets the flag MUDFLAG which is sampled regularly during PHASE1 of sampling.

36:1 SERIAL

Should an interrupt ever be generated by the serial interface it will be vectored here to disable the interrupt.

36:3 TIMER-O'FLOW

This interrupt like SERIAL should never happen, but if it does it is disabled here.

36:5 LINK

add n ---

Interrupts vector through high addresses in the ROM containing the language; to avoid having to reprogram this ROM every time a service routine is relocated, the vectors point to a table of jumps in RAM. When FORTH starts up from cold the jump table is filled in with default addresses. LINK must be used to overwrite these addresses with the addresses of the service routines. n is the jump number.

n	interrupt service routine
0	SERIAL
1	TIMER-O'FLOW
2	TISR
3	SISR
4	MSISR

Used thus ' SERIAL 0 LINK

36:9 GETSET

This initialises ports, clears some flags, enables interrupts and turns on the supplies for the sensors.

37:1 TABLE1,TABLE2
37:2 TABLE3

Three arrays of type CHANNEL-TABLE are declared.

37:2 TABLE

This variable is declared and initialised to point into TABLE1

37:.. The remainder of the program variables and arrays are declared.

38:1 CURRENT-TABLE

n ---

The value of n can be 1,2 or 3 . The variable TABLE is filled with the address of the corresponding table. If n is out of range no change is made.

38:6 TABLE?

--- "string"

Prints the name of the table currently pointed to by TABLE.

38:10 READ-TABLE

The parameters in the current table are displayed in a tabulated form.

39:1 TABLE-ENTRY

n1 n2 n3 n4 ---

Parameters n2,n3 and n4 are filled into channel n1 of the current table. n1 is treated modulo 8 so no damage can be done if n1 is not in the range 0 to 7. The modified contents of the table are then displayed using READ-TABLE.

39:4 READ-LIST

This word prints out the values in the PING-LIST. See notes for the function of the PING-LIST

39:6 SCALE

n1 n2 --- n3

The sensor value n1 is scaled according to the parameters of channel n2 of the current table. n3 is the scaled result. See notes for further imformation about scaling.

39:11 SORT

This word takes the PING-LIST and rearranges its contents into ascending numerical order.

40:1 CHECK

Like SORT this word processes the PING-LIST - It eliminates possible negative delays, delays that are too long or pairs of delays that are too close. At present it is biassed towards dropping the later of two delays less than 20 msec. apart.

40:10 RELATIVES

This word converts a list of delays from zero in the PING-LIST into a list of delay differences. See notes for the details of PING-LIST editing.

41:1 LIST1
42:1 LIST2
43:1 LIST3

These LIST words read the next samples from selected arrays, SCALEs them and enters them into the PING-LIST. The order in which the sensors are read is irrelevant as the PING-LIST will be SORTed later.

44:1 SAMPLE

n1 --- n2

This is the procedure that samples analogue channel n1 and delivers a signed value n2 between -2047 and +2048. First the channel number is fed to the multiplexer then the sample-and-hold chip is switched to hold and a conversion triggered. At the end of conversion the sample-and-hold chip is returned to the sampling state and the output from the analogue to digital converter is inverted (negative logic is used) and adjusted to represent a 2's complement number.

44:7 DELAY

ud ---

This word is the heart of the pulse interval telemetry. The unsigned double precision number ud is split into a high and a low word. The low word is added into the 16 bit counter to produce a delay of that number of micro-seconds. If the high byte is non-zero then it represents the number of complete cycles of count that must be executed before the counter reaches its target and the delay is finished. The high order word is stored in OVER-FLOWS and the timer interrupt is enabled. Each time the target count is reached an interrupt occurs and OVER-FLOWS is decremented.

A crucial aspect of DELAY is that it does not waste "ud" micro-seconds instead it waits for any previous delay to time-out then sets up the new delay and returns. See notes for a more detailed explanation of the use of the timer.

45:1 PULSE

n ---

Generate a transmission pulse of n half-cycles. This word waits for any current delay to time out, saves the state of the count for later and turns on the AGC mute. This will be turned off again by the following DELAY and prevents the receiver gain being affected by the pulse. The power transistors are toggled on and off "n" times to generate the pulse. Before returning the count saved at the start has 10 mSec. added to it so that the whole word takes 10 mSec. to run regardless of the actual time taken to execute the soft-ware. This coherent timing principle is described in more detail later.

45:8 WAIT

This word is used during transponding and waits for a signal interrupt with a delay running. A return occurs either when the interrupt has occurred and cleared SIGFLAG or because the time has run out in which case SIGFLAG will still be set.

45:11 DOWN?

n1 --- (n2)

This word is called regularly after each fast sampling of an accelerometer. n1 is a sampled value but if the optical switch is not yet enabled it is dropped and DOWN? returns. If an optical switch interrupt has occurred MUDFLAG will be set and n2 is set to 2. Otherwise the value of n1 is compared with a threshold and after 10 values have exceeded it n2 is set to 1 . With n2 either 1 or 2 DOWN? performs an exceptional return by exitting 2 levels of DO LOOP. Should these loops exit in the normal way then a value of zero is left on the stack.

Thus 0 means bottom not detected within the time allowed.

1 means a significant deceleration has ocurred.

2 means the optical switch has worked.

DOWN? will cause a crash if not called within a double DO LOOP!

46:1 PREPARE1
46:2 PREPARE2
46:3 PREPARE3

These words fetch, scale data and edit them into the PING-LIST

46:4 P15?
--- f
The state of the optical switch is read through port1 bit 5 and returned as f, a boolean flag.

46:5 PING
35 half-cyles = 5 mSec. at 3.5 kHz.

46:6 WATER?

The unblocked state of the optical switch is tested 10 times a second. As long as this state is false PINGs are generated every 10 seconds.

46:8 TRANSMIT

This word actually implements the pulse interval telemetry by reading a PING-LIST of delays. If a value is non-zero then a 5 mSec. PING is generated and a DELAY corresponding the value is started. If a zero value is read then TRANSMIT exits immediately. (At least one zero value at the end of the list is guaranteed).

46:11 SYNC.

It is neccessary to synchronise the timing of delays and pings with the arrival time of received signals. The narrow-band signal has a slow rise and if the time at which it passes the detector threshold is used there will be some jitter as the amplitude of the pulses vary. The detector pulse is sensed on a timer input line to generate an interrupt but at the same time the current state of the counter is captured. SYNC. provisionally uses this count to set up a delay of 10 mSec. and then starts sampling the signal through channel zero. It makes 10 attempts to find a peak and if it does it uses the time this occurs as a timing reference since it is essentially independent of the signal amplitude. If no peak is found then the timing defaults to 10 mSec. from detector transision.
The highest value of signal sampled is stored in the variable SIGNAL and can transponded back to the ship so that adjustments to the transmitted interogation pulse can be made.

47:1 RESET
add ---
This word resets a ROLLING-BUFFER or auto-incrementing ARRAY+ given the run-time address of the array. Used thus :-
' TILT2 RESET

47:2 BACKUP

add n ---

Data is being continually sampled at 500 Hz. into ROLLING-BUFFERs from the instant of launch. When the mud is sensed sampling continues for a further fixed time (2 Sec. currently). In order to preserve some of the data sampled before landing the ROLLING-BUFFERs can be backed-up say 2.5 Sec.

"add" is the run time address of the particular ROLLING-BUFFER and "n" the positive number of samples to be backed-up. BACKUP is aware of the cyclic nature of the buffers. Used thus :-

' ACELNRB1 1250 BACKUP

47:6 TRANSFER

The ROLLING-BUFFERS consume much of the data storage space but only a portion of them contain interesting data. This portion is TRANSFERed to auto-incrementing arrays after being backed-up by the ammount in BACKBY so that the data space can be reallocated to store slow-sampled data.

47:11 CLEAR

This word RESETS all the medium-sampled data arrays in one go.

49:2 PHASE1

n ---

This sampling procedure takes 1/10 Sec. to cycle through once. n is the number of cycles. Fast data is sampled every 2 mSecs. and every 100 mSecs. a complete set of medium data is also sampled. However, as this latter cannot be completed in 2 mSecs., 4 mSecs. is allowed with the fast data being sampled twice in this time.

DOWN? tests for the arrival at the sediment only if the optical switch is enabled to interrupt and this can be delayed say 1 minute into the descent to prevent false triggering during and immediately after launch.

50:2 PHASE2

n ---

This routine is similar to PHASE1 except that DOWN? is not called. However, having a separate routine allows the duration of post-trigger sampling to be chosen independently.

51:1 SAMPLE-NOW

This samples sensors into variables for immediate live transmission.

51:6 MARK

n ---

After PHASE1 and PHASE2 of sampling the number left on the stack indicates the way in which PHASE1 was exitted. If this is 2, the optical switch triggered, MARK backs up through the accelerometer arrays to the trigger instant and adds a small offset to 5 samples of accelerometer 1.

51:11 PREPARE4

Only the received signal level is transmitted during transponding. PREPARE4 replaces negative values of SIGNAL by zero, scale the values down by 8 and provides an offset of 20 mSecs. This value is entered into the PING-LIST and the remaining values zeroed before the list is editted.

52:1 FAST-DATA-PINGING
n ---

This performs n 2 second cycles of data transmission from the fast sampled data arrays. TIME-ERROR contains a small number which adjusts the time of the whole loop to exactly 2 seconds by taking into account the initial tolerance of the crystal oscillator.

52:5 MEDIUM-DATA-PINGING
52:9 LIVE-PINGING
n ---

These do the same job as FAST-DATA-PINGING on medium and live data respectively.

52:13 READY?

This complicated and messy routine performs a simple function. PINGs are generated once per minute as long as the optical switch is unblocked. The state of the optical switch is tested every 1/10 Sec. and should it remain continuously blocked for 30 Secs. the routine exits.

53:1 TRANSPOND
n ---

This performs n 2 Second cycles of transponding. If SYNC. detects a pulse in a 10 mSec. window the a reference pulse followed by the signal data pulse are transmitted. There is a pause until the signal interrupt is enabled at the beginning of the next window. Should there be no pulse the reference pulse alone is transmitted indented by an additional 10 mSecs. and after 1 second the signal interrupt is enabled.

Thus if the pulse is missed a 1 second window is opened so there is a 50% chance of the transponder synchronising. If the interogation pulse is outside this window the operator need only jump the phase of the 2 second pulses by one second by switching from edge to centre keying or vice versa.

54: PARAMETERS
--- n

HERE places the value of the current dictionary pointer on the stack and the interpreter precedes to execute the instructions to store successive 16 bit values into the dictionary. A constant is then declaring with the value left by HERE.

This table is used later by SETUP to fill the scaling tables with reasonable default values and initialise the cycle number variables NO.1 to NO.9.

55:1 FILL-TABLE

n1 n2 ---

This is a DO LOOP that fills 24 constants from the table of PARAMETERs into one of the scaling tables. n1 is the limit and n2 the initial value for the DO LOOP.

55:3 SETUP

SETUP first zeroes all the data space in RAM then uses FILL-TABLE to copy default values into the scaling tables. Other constants including a default value for TIME-ERROR are then copied into their respective variables. SETUP ends by executing GETSET so if no changes are to be made the main program can be run immediately.

56:1 JRC

n ---

This executes n 2 second cycles of transmission of the data from one accelerometer using a modifed form of P.I.T.. To encode one 12 bit word into P.I.T. using a 2 Sec. repetition rate would require a time resolution of 2/4096 or about 1/2 mSec. but if the 12 bits is split into two channels of 6 bits each occupying a third of the time the minimum time to be resolved increases by 64/3 to say 10 mSec.and should thus be more easily decoded by an autonomous listening station for subsequent transmission by satelite to a ground station.

The sequence starts with four synchonising pulses spaced by the binary intervals 50, 100 and 200 mSec. If one or two of these pulses are missing it should be possible to reconstruct the timing as each possible pair of pulses has a unique time separation.

For each of the 2 six bit groups one pulse is generated in one of 64 ten mSec. cells.

APPENDIX A5 SOFTWARE NOTES

A5. NOTES

(1) TFORTH Conventional FORTH is a list processing language and has a kernel which interprets the high level words. This structure is an advantage to the language as the kernel only requires a primitive instruction set and can thus be implemented on a wide variety of computers. However, the imposition of the inner interpreter between every word executed has a time penalty.

The action of threading through nested words by the FORTH virtual machine is nearly equivalent to the way CPU would tackle nested subroutines. TFORTH has been developed to compile words as a series of 3 byte subroutine calls rather than as lists of 2 byte addresses and terminates them with a subroutine return instruction. The result is run-time code which takes slightly more memory but is quicker.

To the user the language behaves exactly like FORTH and retains all its other characteristics.

(2) THE TIMER The HD 6303 microprocessor has an internal 16 bit counter which is clocked continuously at 1 MHz. Associated with the counter are three registers:-

The input capture register that makes a copy of the current count when a transition occurs on the timer input line.

A register that freezes the count when accessed; the counter runs on though.

The output compare register which can be loaded with a target count such that when the counter matches this value a previously programmed 0 or 1 is output to the timer output pin (not used in this application), a flag is set and an interrupt may be generated.

By adding a new delay onto the previous target and making this the new target a series of contiguous time delays can be generated independent of the time taken by the software, provided delays are kept greater than about 40 microseconds.

To generate delays longer than 2 16 microseconds the target value is set up using the least significant 16 bits of the delay and an interrupt enabled. Each time the count passes the target an interrupt is generated and the high order part of the delay is decremented.

A problem might arise if, although the total delay is large (100s of msec), the least significant 16 bits is small. In this case the counter will have passed the target before the software has set it up so an extra full cycle will be added to the delay.

DELAY adds 128 to any residual that was less than 128 and sets a flag (CORRFG) which enables the interrupt service to knock 128 off the last cycle of count. With delays resolved to the nearest 1 msec the problem only occurred at one value of delay, 852 msec since this is equal to 13 * 2 16 + 32.

An important feature of DELAY is that it does not waste the specified delay instead it initially waits for any previous delay to be complete, sets up the new delay and then returns to allow additional software to executed while the delay is running.

(3) SCALING SCALE multiplies a signed 12 bit digitised value from a sensor by a/b and adds an offset c.

a = the full scale time delay
b = the full scale digitised value
c = some additional time delay in msecs.

If, for example, an accelerometer generates +10 g full scale this is equivalent to +5 volts and +2048 when digitised. We require a display with 100 msec = 1 g therefore:-

a = 10*100 = 1000
b = 2048

and c is chosen to displace 0 g away from the reference ping say by 100 msec. Before the offset is added the scaled value is reduced modulo a. This allows a smaller value of b to be used to magnify the display without the delay going outside the bounds of + or -a. If in

the above example b was chosen to be 1024, 1000 msec would now represent 5 g, i.e. 200 msec/g but 6 g would be displayed as 1 g, 7 g as 2 g, etc.

Small adjustments to a, b and c can be made to compensate for sensor gain or offset errors.

(4) PING-LIST EDITING The scaling process might generate unobtainable values of delay, say negative values or values greater than 2000 msec. The time delays originally entered into the PING-LIST would normally be in channel-number order and each represents a delay from zero. The word TRANSMIT requires a series of delays from the end of one PING to the beginning of the next.

SORT puts the delays into ascending numerical order so that the successive differences are all positive.

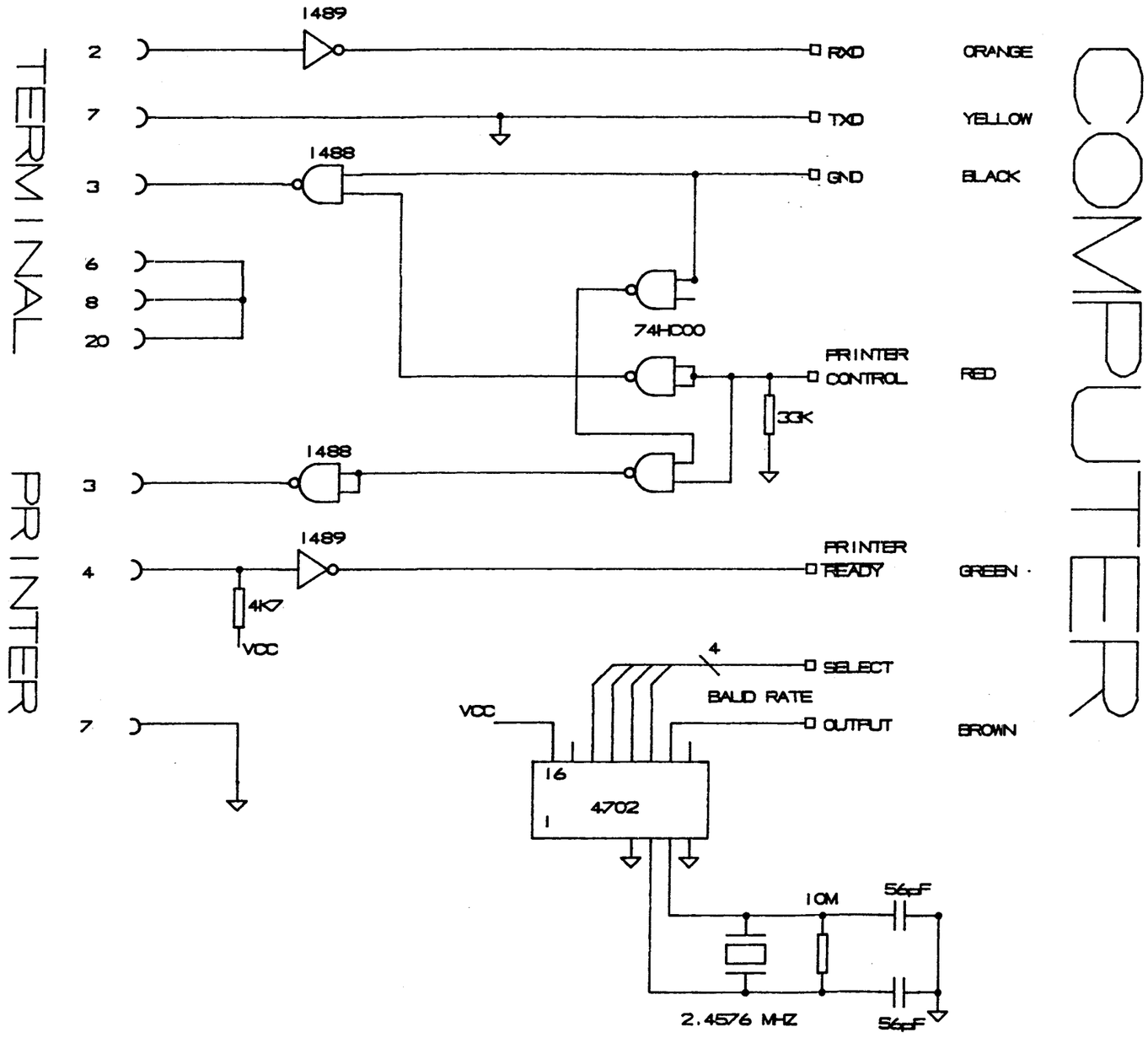
CHECK removes or substitutes any rogue values that are too large, too small (or negative) and deletes the second of any pair that differ by less than 20 msec.

RELATIVES converts the CHECKed list into a series of delays between PINGs.

APPENDIX A6 CIRCUIT DIAGRAMS

OPT2
22p
22p
4MHZ
+5
10K
1M0
TP2
HD6303
VSS
XTAL
EXTAL
NMI
IRQ
RES
STBY
P20
P21
P22
P23
P24
P10
P11
P12
P13
P14
P15
P16
P17
E
AS
R/W
D/A0
D/A1
D/A2
D/A3
D/A4
D/A5
D/A6
D/A7
A8
A9
A10
A11
A12
A13
A14
A15
VCC
PPA1
PPA2
MUTE
1.0
10
CD4053
SIO
TP4
SERIAL INTERFACE
6 5 4 3 2 1
TP3
74HC373
8
TP1
A0-7
A8-A15
A12
A13
R/W
D0-D7
A0-A7
TO EXTERNAL MEMORY VIA 34 WAY CONNECTOR
27C64
VPP VCC
A12 WE
A7 CS2
A6 A8
A5 A9
A4 A11
A3 OE
A2 A10
A1 CS1
A0 D7
D0 D6
D1 D5
D2 D4
VSS D3
TP5
A8-A15
04
2 A0-A1
SW1
MUX
SWITCH
ANALOGUE
10K
HD6321
CA1
CA2
IRQA
IRQB
RES
CS1
CS2
R/W
VSS
PA0
PA1
PA2
PA3
PA4
PA5
PA6
PA7
PB0
PB1
PB2
PB3
PB4
PB5
PB6
PB7
CB1
CB2
PA0-3
MUX
OPT1
PB0-7
MUX SEL LO
MUX SEL HI
EOC
ADC START
ADC CLOCK
74HC74
74HC139
2
A11-A13
A11
A12
A13
00
18
08
TP8
74HC04
PIN 1 TO VCC
VIA 1.0 OHM
10
TP6
TP7
74HC00
TP9
100nF CER 22 TANT
REG. +5V
0V
VCC

INSTITUTE OF OCEANOGRAPHIC SCIENCES PATSY	TITLE: MICROPROCESSOR	DATE:	10/1/85
		SHEET:	1
		ISSUE:	



INSTITUTE OF OCEANOGRAPHIC SCIENCES PATSY	TITLE: SERIAL INTERFACE	DATE:	28/2/86
		SHEET:	2
		ISSUE:	

350 T 0.5mm
1.4mm AIR GAP

LA1221
330 T .28mm
32 mH
68nF 250V
190 T

FX2243
190 T
32 mH
.45mm

TO TRANSDUCER

FX3730
.45mm
24 T
24 T
1.0
36V
1K2
DR1
82V
82V
1K2
DR2
THERMALLY COUPLED
RS 307 929
RS 307 929
BDT65A
2X
4.7 mF
BDT65A

PULSE POWER AMPLIFIER

+12V
5K6
BC479
10K
SUPPLY SW
4K7
BC109
+VA
BC479
-VA
10K
BC109
5K6
-12V

MUX SEL HI
DG508
11 10 9 8
15 14 13 12
MUX SEL LO
3 2 1 0
DG508
7 6 5 4
MUX
PA4
PA5
PA6
ANAL ⊥ LOGIC GND

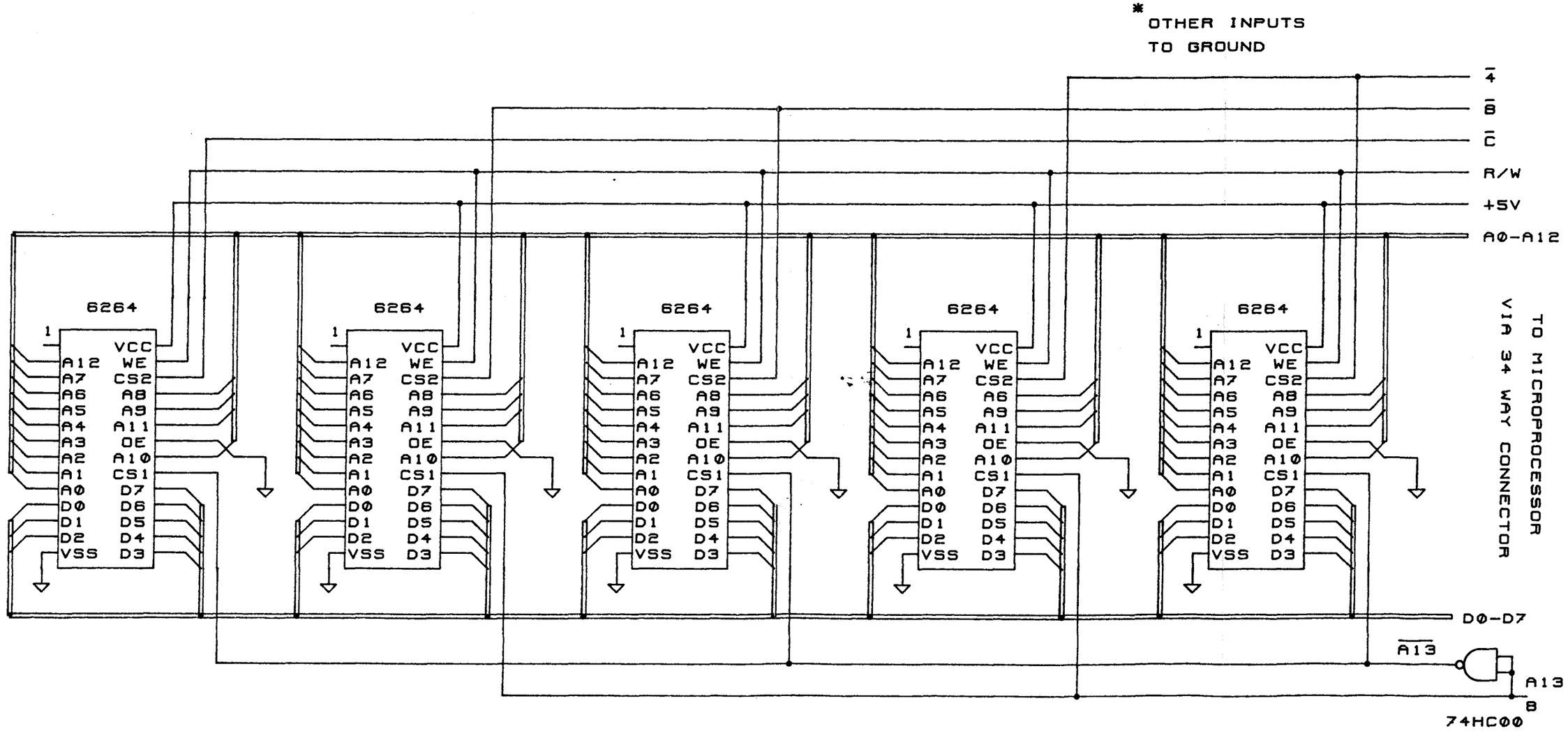
1nF POLYPROPYLENE
EOC
ADC START
PA0-3
ACC1210
SC
QC
PA3
PA2
PA1
PA0
PB7
PB6
PB5
PB4
PB3
PB2
PB1
PB0
IN
Vref
CO
CLK

100n
820
TP10
ZERO
CAL
1K
10K
5K0
100n
100K
22
22
ZNREF05
PB0-7
ADC CLOCK
5K6
+9V
ZN3904
CD40109B
+5
PPA1
PPA2
10K
10K
DR2
DR1

+3V
10
TUNE
47K
1K0
2n2
820K
2n2
BOTH
BC109C
10K
10M
100n
VC
*
68n
4K7
BFW54
BFW54
* APROX 5M6 FOR VC +0.5
33K
PIN 13
8 9
470K
2M2
10
CD4007
TUNE
1K0
1n5
820K
1n5
10K
GAIN
470K
500K 10 T
100K
1K0
470n
470K
BC109
220K
220K
TP11
2K2
PIN 4 LM346
1M2
180K
1M6
100K
THRESHOLD
22K
BC109
470K
-3V
LM346
LM346
CD4007
14
8
7
12
6
9
10
SIG
GROUND PLANE THIS SIDE
MUTE

RECEIVER

INSTITUTE OF OCEANOGRAPHIC SCIENCES PATSY	TITLE	ANALOGUE	DATE: 1/11/85
			SHEET: 3
			ISSUE:



INSTITUTE OF OCEANOGRAPHIC SCIENCES PATSY	TITLE: MEMORY	DATE:	13/3/86
		SHEET:	4
		ISSUE:	