```
stars by prs  for s/w 2b

6077/

/stars 1 • 3/13/62, prs.

        decimal

        define
mark X, Y
        repeat 8, Y=Y+Y
        8192-X      Y
        terminate

1j,     mark 1537, 371      /87 Taur, Aldebaran
        mark 1762, -189     /19 Orio, Rigel
        mark 1990, 168      /58 Orio, Betelgeuze
        mark 2280, -377     /9 CMaj, Sirius
        mark 2583, 125      /10 CMin, Procyon
        mark 3431, 283      /32 Leon, Regulus
        mark 4551, -242     /67 Virg, Spica
        mark 4842, 448      /16 Boot, Arcturus
1q,     mark 6747, 196      /53 Aqil, Altair

2j,     mark 1819, 143      /24 Orio, Bellatrix
        mark 1884, -29      /46 Orio
        mark 1910, -46      /50 Orio
        mark 1951, -221     /53 Orio
        mark 2152, -407     / 2 CMaj
        mark 2230, 375      /24 Gemi
        mark 3201, -187     /30 Hyda, Alphard
        mark 4005, 344      /94 Leon, Denebola
2q,     mark 5975, 288      /55 Ophi

3j,     mark   46, 333      /88 Pegs, Algenib
        mark  362, -244     /31 Ceti
        mark  490, 338      /99 Pisc
        mark  566, -375     /52 Ceti
        mark  621, 462      / 6 Arie
        mark 764, -78       /68 Ceti, Mira
        mark  900, 64       /86 Ceti
        mark 1007, 84       /92 Ceti
        mark 1243, -230     /23 Erid
        mark 1328, -314     /34 Erid
        mark 1495, 432      /74 Taur
        mark 1496, 356      /78 Taur
        mark 1618, 154      / 1 Orio
        mark 1644, 52       / 8 Orio
        mark 1723, -119     /67 Erid
        mark 1755, -371     / 5 Leps
        mark 1779, -158     /20 Orio
        mark 1817, -57      /28 Orio
        mark 1843, -474     / 9 Leps
        mark 1860, -8       /34 Orio
        mark 1868, -407     /11 Leps
        mark 1875, 225      /39 Orio
        mark 1880, -136     /44 Orio
        mark 1887, 480      /123 Taur
        mark 1948, -338     /14 Leps
        mark 2274, 296      /31 Gemi
```

mark 2460, 380 /54 Gemi

mark 2470, 504 /55 Gemi
mark 2513, 193 / 3 CMin
mark 2967, 154 /11 Hyda
mark 3016, 144 /16 Hyda
mark 3424, 393 /30 Leon
mark 3496, 463 /41 Leon, Algieba
mark 3668, -357 /nu Hyda
mark 3805, 479 /68 Leon
mark 3806, 364 /10 Leon
mark 4124, -502 / 2 Corv
mark 4157, -387 / 4 Corv
mark 4236, -363 / 7 Corv
mark 4304, -21 /29 Virg
mark 4384, 90 /43 Virg
mark 4421, 262 /47 Virg
mark 4606, -2 /79 Virg
mark 4721, 430 / 8 Boot
mark 5037, -356 / 9 Libr
mark 5186, -205 /27 Libr
mark 5344, 153 /24 Serp
mark 5357, 358 /28 Serp
mark 5373, -71 /32 Serp
mark 5430, -508 / 7 Scor
mark 5459, -445 / 8 Scor
mark 5513, -78 / 1 Ophi
mark 5536, -101 / 2 Ophi
mark 5609, 494 /27 Herc
mark 5641, -236 /13 Ophi
mark 5828, -355 /35 Ophi
mark 5860, 330 /64 Herc
mark 5984, -349 /55 Serp
mark 6047, 63 /62 Ophi
mark 6107, -222 /64 Ophi
mark 6159, 217 /72 Ophi
mark 6236, -66 /58 Serp
mark 6439, -483 /37 Sgtr
mark 6490, 312 /17 Aqil
mark 6491, -115 /16 Aqil
mark 6507, -482 /41 Sgtr
mark 6602, 66 /30 Aqil
mark 6721, 236 /50 Aqil
mark 6794, 437 /12 Sgte
mark 6862, -25 /65 Aqil
mark 6914, -344 / 9 Capr
mark 7014, 324 / 6 Dlph
mark 7318, -137 /22 Aqar
mark 7391, 214 / 8 Pegs
mark 7404, -377 /49 Capr
mark 7513, -18 /34 Aqar
mark 7539, 130 /26 Pegs
mark 7644, -12 /55 Aqar
mark 7717, 235 /42 Pegs
mark 7790, -372 /76 Aqar
3q, mark 7849, 334 /54 Pegs, Markab

4j,

mark 1, -143 /33 Pisc
mark 54, 447 /89 Pegs
mark 54, -443 / 7 Ceti
mark 82, -214 / 8 Ceti
mark 223, -254 /17 Ceti
mark 248, 160 /63 Pisc
mark 273, -38 /20 Ceti
mark 329, 167 /71 Pisc
mark 376, 467 /84 Pisc
mark 450, -198 /45 Ceti
mark 548, 113 /106 Pisc
mark 570, 197 /110 Pisc
mark 595, -255 /53 Ceti
mark 606, -247 /55 Ceti
mark 615, 428 / 5 Arie
mark 617, 61 /14 Pisc
mark 656, -491 /59 Ceti
mark 665, 52 /113 Pisc
mark 727, 191 /65 Ceti
mark 803, -290 /72 Ceti
mark 813, 182 /73 Ceti
mark 838, -357 /76 Ceti
mark 878, -2 /82 Ceti
mark 907, -340 /89 Ceti
mark 908, 221 /87 Ceti
mark 913, -432 / 1 Erid
mark 947, -487 / 2 Erid
mark 976, -212 / 3 Erid
mark 992, 194 /91 Ceti
mark 1058, 440 /57 Arie
mark 1076, 470 /58 Arie
mark 1087, -209 /13 Erid
mark 1104, 68 /96 Ceti
mark 1110, -503 /16 Erid
mark 1135, 198 / 1 Taur
mark 1148, 214 / 2 Taur
mark 1168, 287 / 5 Taur
mark 1170, -123 /17 Erid
mark 1185, -223 /18 Erid
mark 1191, -500 /19 Erid
mark 1205, 2 /10 Taur
marc 1260, -283 /26 Erid
mark 1304, -74 /32 Erid
mark 1338, 278 /35 Taur
mark 1353, 130 /38 Taur
mark 1358, 497 /37 Taur
mark 1405, -162 /38 Erid
mark 1414, 205 /47 Taur
mark 1423, 197 /49 Taur
mark 1426, -178 /40 Erid
mark 1430, 463 /50 Taur
mark 1446, 350 /54 Taur
mark 1463, 394 /61 Taur
mark 1470, 392 /64 Taur
mark 1476, 502 /65 Taur
mark 1477, 403 /68 Taur

mark 1483, 350 /71 Taur
mark 1485, 330 /73 Taur
mark 1495, 358 /77 Taur
mark 1507, 364 /
mark 1518, -6 /45 Erid
mark 1526, 333 /86 Taur
mark 1537, 226 /88 Taur
mark 1544, -81 /48 Erid
mark 1551, 280 /90 Taur
mark 1556, 358 /92 Taur
mark 1557, -330 /53 Erid
mark 1571, -452 /54 Erid
mark 1596, -78 /57 Erid
mark 1622, 199 / 2 Orio
mark 1626, 124 / 3 Orio
mark 1638, -128 /61 Erid
mark 1646, 228 / 7 Orio
mark 1654, 304 / 9 Orio
mark 1669, 36 /10 Orio
mark 1680, -289 /64 Erid
mark 1687, -167 /65 Erid
mark 1690, -460 /
mark 1690, 488 /102 Taur
mark 1700, 347 /11 Orio
mark 1729, 352 /15 Orio
mark 1732, -202 /69 Erid
mark 1750, -273 / 3 Leps
mark 1753, 63 /17 Orio
mark 1756, -297 / 4 Leps
mark 1792, -302 / 6 Leps
mark 1799, -486 /
mark 1801, -11 /22 Orio
mark 1807, 79 /23 Orio
mark 1816, -180 /29 Orio
mark 1818, 40 /25 Orio
mark 1830, 497 /114 Taur
mark 1830, 69 /30 Orio
mark 1851, 134 /32 Orio
mark 1857, 421 /119 Taur
mark 1861, -168 /36 Orio
mark 1874, 214 /37 Orio
mark 1878, -138 /
mark 1880, -112 /42 Orio
mark 1885, 210 /40 Orio
mark 1899, -60 /48 Orio
mark 1900, 93 /47 Orio
mark 1900, -165 /49 Orio
mark 1909, 375 /126 Taur
mark 1936, -511 /13 Leps
mark 1957, 287 /134 Taur
mark 1974, -475 /15 Leps
mark 1982, 461 /54 Orio
mark 2002, -323 /16 Leps
mark 2020, -70 /
mark 2030, 220 /61 Orio

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mark 2032, -241     / 3 Mono
mark 2037, 458      /62 Orio
mark 2057, -340     /18 Leps
mark 2059, 336      /67 Orio
mark 2084, 368      /69 Orio
mark 2084, 324      /70 Orio
mark 2105, -142     / 5 Mono
mark 2112, -311     /
mark 2153, 106      / 8 Mono
mark 2179, 462      /18 Gemi
mark 2179, -107     /10 Mono
mark 2184, -159     /11 Mono
mark 2204, 168      /13 Mono
mark 2232, -436     / 7 CMaj
mark 2239, -413     / 8 CMaj
mark 2245, -320     /
mark 2250, 227      /15 Mono
mark 2266, 303      /30 Gemi
mark 2291, 57       /18 Mono
mark 2327, 303      /38 Gemi
mark 2328, -457     /15 CMaj
mark 2330, -271     /14 CMaj
mark 2340, -456     /19 CMaj
mark 2342, -385     /20 CMaj
mark 2378, -93      /19 Mono
mark 2379, 471      /43 Gemi
mark 2385, -352     /23 CMaj
mark 2428, -8       /22 Mono
mark 2491, -429     /
mark 2519, 208      / 4 CMin
mark 2527, 278      / 6 CMin
mark 2559, -503     /
mark 2597, -212     /26 Mono
mark 2704, -412     /
mark 2709, -25      /28 Mono
mark 2714, 60       /
mark 2751, -61      /29 Mono
mark 2757, -431     /16 Pupp
mark 2768, -288     /19 Pupp
mark 2794, 216      /17 Canc
mark 2848, -82      /
mark 2915, 138      / 4 Hyda
mark 2921, 84       / 5 Hyda
mark 2942, -355     / 9 Hyda
mark 2944, 497      /43 Canc
mark 2947, 85       / 7 Hyda
mark 2951, -156     /
mark 2953, 421      /47 Canc
mark 2968, -300     /12 Hyda
mark 2976, 141      /13 Hyda
mark 3032, 279      /65 Canc
mark 3124, 62       /22 Hyda
mark 3157, -263     /26 Hyda
mark 3161, -208     /27 Hyda
mark 3209, -53      /31 Hyda
mark 3225, -17      /32 Hyda
mark 3261, 116      /
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mark 3270, -16 /35 Hyda
mark 3274, -316 /38 Hyda
mark 3276, 236 /14 Leon
mark 3338, -327 /39 Hyda
mark 3385, 194 /29 Leon
mark 3415, -286 /40 Hyda
mark 3428, 239 /31 Leon
mark 3429, 3 /15 Sext
mark 3446, -270 /41 Hyda
mark 3495, 455 /40 Leon
mark 3534, -372 /42 Hyda
mark 3557, -3 /30 Sext
mark 3570, 223 /47 Leon
mark 3726, -404 /a1 Crat
mark 3736, -44 /61 Leon
mark 3738, 471 /60 Leon
mark 3754, 179 /63 Leon
mark 3793, -507 /11 Crat
mark 3821, -71 /74 Leon
mark 3836, -324 /12 Crat
mark 3846, 150 /77 Leon
mark 3861, 252 /78 Leon
mark 3868, -390 /15 Crat
mark 3935, -211 /21 Crat
mark 3936, -6 /91 Leon
mark 3981, -405 /27 Crat
mark 3986, 161 / 3 Virg
mark 3998, 473 /93 Leon
mark 4013, 53 / 5 Virg
mark 4072, 163 / 8 Virg
mark 4097, 211 / 9 Virg
mark 4180, -3 /15 Virg
mark 4185, 418 /11 Coma
mark 4249, -356 / 8 Corv
mark 4290, -170 /26 Virg
mark 4305, 245 /30 Virg
mark 4376, -205 /40 Virg
mark 4403, 409 /36 Coma
mark 4465, -114 /51 Virg
mark 4466, 411 /42 Coma
mark 4512, -404 /61 Virg
mark 4563, -352 /69 Virg
mark 4590, -131 /74 Virg
mark 4603, 95 /78 Virg
mark 4679, 409 / 4 Boot
mark 4691, 371 / 5 Boot
mark 4759, 46 /93 Virg
mark 4820, 66 /
mark 4822, -223 /98 Virg
mark 4840, -126 /99 Virg
mark 4857, -294 /100 Virg
mark 4864, 382 /20 Boot
mark 4910, -41 /105 Virg
mark 4984, 383 /29 Boot
mark 4986, 322 /30 Boot
mark 4994, -119 /107 Virg

mark 5009, 396 /35 Boot
mark 5013, 53 /109 Virg
mark 5045, 444 /37 Boot
mark 5074, -90 /16 Libr
mark 5108, 57 /110 Virg
mark 5157, -442 /24 Libr
mark 5283, -221 /37 Libr
mark 5290, -329 /38 Libr
mark 5291, 247 /13 Serp
mark 5326, -440 /43 Libr
mark 5331, 455 /21 Serp
mark 5357, 175 /27 Serp
mark 5372, 420 /35 Serp
mark 5381, 109 /37 Serp
mark 5387, 484 /38 Serp
mark 5394, -374 /46 Libr
mark 5415, 364 /41 Serp
mark 5419, -318 /48 Libr
mark 5455, -253 /xi Scor
mark 5467, -464 / 9 Scor
mark 5470, -469 /10 Scor
mark 5497, -437 /14 Scor
mark 5499, -223 /15 Scor
mark 5558, 29 /50 Serp
mark 5561, 441 /20 Herc
mark 5565, -451 / 4 Ophi
mark 5580, 325 /24 Herc
mark 5582, -415 / 7 Ophi
mark 5589, -186 / 3 Ophi
mark 5606, -373 / 8 Ophi
mark 5609, 50 /10 Ophi
mark 5610, -484 / 9 Ophi
mark 5620, 266 /29 Herc
mark 5713, -241 /20 Ophi
mark 5742, 235 /25 Ophi
mark 5763, 217 /27 Ophi
mark 5807, 293 /60 Herc
mark 5868, -8 /41 Ophi
mark 5888, -478 /40 Ophi
mark 5889, -290 /53 Serp
mark 5924, -114 /
mark 5925, 96 /49 Ophi
mark 5987, -183 /57 Ophi
mark 6006, -292 /56 Serp
mark 6016, -492 /58 Ophi
mark 6117, -84 /57 Serp
mark 6117, 99 /66 Ophi
mark 6119, 381 /93 Herc
mark 6119, 67 /67 Ophi
mark 6125, 30 /68 Ophi
mark 6146, 57 /70 Ophi
mark 6158, 198 /71 Ophi
mark 6170, 473 /102 Herc
mark 6188, -480 /13 Sgtr
mark 6234, 76 /74 Ophi
mark 6235, 499 /106 Herc

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mark 6247, -204    /xi Scut
mark 6254, -469    /21 Sgtr
mark 6255, 494     /109 Herc
mark 6278, -333    /ga Scut
mark 6313, -189    /al Scut
mark 6379, 465     /110 Herc
mark 6382, -110    /be Scut
mark 6386, 411     /111 Herc
mark 6436, 93      /63 Serp
mark 6457, 340     /13 Aqil
mark 6465, -134    /12 Aqil
mark 6478, -498    /39 Sgtr
mark 6553, 483     / 1 Vulp
mark 6576, -410    /44 Sgtr
mark 6576, -368    /46 Sgtr
mark 6607, 3       /32 Aqil
mark 6651, 163     /38 Aqil
mark 6657, 445     / 9 Vulp
mark 6665, -35     /41 Aqil
mark 6688, 405     / 5 Sgte
mark 6693, 393     / 6 Sgte
mark 6730, 416     / 7 Sgte
mark 6739, 430     / 8 Sgte
mark 6755, 17      /55 Aqil
mark 6766, 187     /59 Aqil
mark 6772, 140     /60 Aqil
mark 6882, 339     /67 Aqil
mark 6896, -292    / 5 Capr
mark 6898, -292    / 6 Capr
mark 6913, -297    / 8 Capr
mark 6958, -413    /11 Capr
mark 6988, 250     / 2 Dlph
mark 7001, 326     / 4 Dlph
mark 7015, -33     /71 Aqil
mark 7020, 475     /29 Vulp
mark 7026, 354     / 9 Dlph
mark 7047, 335     /11 Dlph
mark 7066, 359     /12 Dlph
mark 7067, -225    / 2 Aqar
mark 7068, -123    / 3 Aqar
mark 7096, -213    / 6 Aqar
mark 7161, -461    /22 Capr
mark 7170, -401    /23 Capr
mark 7192, -268    /13 Aqar
mark 7199, 222     / 5 Equl
mark 7223, 219     / 7 Equl
mark 7230, 110     / 8 Equl
mark 7263, -393    /32 Capr
mark 7267, 441     / 1 Pegs
mark 7299, -506    /36 Capr
mark 7347, -453    /39 Capr
mark 7353, -189    /23 Aqar
mark 7365, -390    /40 Capr
mark 7379, -440    /43 Capr
mark 7394, 384     / 9 Pegs
mark 7499, -60     /31 Aqar
mark 7513, 104     /22 Pegs
```

```
        mark 7515, -327    /33 Aqar
        mark 7575, -189    /43 Aqar
        mark 7603, -43     /48 Aqar
        mark 7604, 266     /31 Pegs
        mark 7624, 20      /52 Aqar
        mark 7639, 96      /35 Pegs
        mark 7654, -255    /57 A ar
        mark 7681, -14     /62 Aqar
        mark 7727, -440    /66 Aqar
        mark 7747, 266     /46 Pegs
        mark 7761, -321    /71 Aqar
        mark 7779, -185    /73 Aqar
        mark 7795, 189     /50 Pegs
        mark 7844, 75      / 4 Pisc
        mark 7862, 202     /55 Pegs
        mark 7874, -494    /88 Aqar
        mark 7903, -150    /90 Aqar
        mark 7911, -219    /91 Aqar
        mark 7919, 62      / 6 Pisc
        mark 7923, -222    /93 Aqar
        mark 7952, -470    /98 Aqar
        mark 7969, -482    /99 Aqar
        mark 7975, 16      / 8 Pisc
        mark 7981, 133     /10 Pisc
        mark 7988, 278     /70 Pegs
        mark 8010, -489    /101 Aqar
        mark 8049, 116     /17 Pisc
        mark 8059, -418    /104 Aqar
        mark 8061, 28      /18 Pisc
        mark 8064, -344    /105 Aqar
        mark 8159, 144     /28 Pisc
        mark 8174, -149    /30 Pisc
4q,     mark 8188, -407    / 2 Ceti

        start 4
```

```
/title punch table

ftp/    0          0          004277     400000
        625151     514600     224145     453200
        141211     771000     274545     453100
        364545     453000     010171     050300
        324545     453200     065151     513600
        0          0          0          0
        0          0          0          0
        0          0          0          0

        364141     413600     402014     020100
        224545     453000     010177     010100
        374040     403700     073060     300700
        376010     603700     412214     224100
        010274     020100     615141     454300
        0          0          141414     141400
        0          0          0          0
        0          0          0          0

        0          0          204040     403700
        771014     224100     774040     404000
        770214     027700     770214     207700
        364141     413600     771111     110600
        364151     215600     771111     314600
        0          0          0          0
        101010     101000     000041     221400
        101074     101000     001422     410000

        0          0          761111     117600
        774545     453200     364141     412200
        774141     413600     774545     414100
        770505     010100     364151     513000
        771010     107700     004177     410000
        010300     010300     000060     600000
        030200     030200

start ps5
```

```
3/          jmp sbf                 / ignore seq. break
            jmp a40
            jmp a1      / use test word for control, not iot 11 cc

/ interesting and often changed constants

/symb loc   usual value (all instructions are executed,
          / and may be replaced by jda or jsp)

tno,  6,    law i 41                / number of torps + 1
tvl,  7,    sar 4s      / torpedo velocity
rlt, 10,    law i 20    / torpedo reload time
tlf, 11,    law i 140               / torpedo life
foo, 12,    -20000      / fuel supply
maa, 13,    10          / spaceship angular acceleration
sac, 14,    sar 4s      / spaceship acceleration
str, 15,    100         / star capture radius
me1, 16,    6000        / collision "radius"
me2, 17,    3000        / above/2
ddd, 20,    -0          / 0 to save space for ddt
the, 21,    sar 9s      / amount of torpedo space warpage
mhs, 22,    law i 10    / number of hyperspace shots
hd1, 23,    law i 40    / time in hyperspace before breakout
hd2, 24,    law i 100               / time in hyperspace breakout
hd3, 25,    law i 200               / time to recharge hyperfield generators
hr1, 26,    scl 9s      / scale on hyperspatial displacement
hr2, 27,    scl 4s      / scale on hyperspatially induced velocity
hur, 30,    40000       / hyperspatial uncertancy
ran, 31,    0           / random number
grv, 32,    sar 6s      / gravitational constant

/ place to build a private control word routine.
/ it should leave the control word in the io as follows.
/ high order 4 bits, rotate ccw, rotate cw, (both mean hyperspace)
/    fire rocket, and fire torpedo. low order 4 bits, same for
/    other ship.  Routine is entered by jsp cwg.

40/

cwr,        jmp mg1     / normally iot 11 control
. 20/       / space
```

```
/ routine to flush sequence breaks, if they occur.

sbf,        cyi
            lio 2
            lac 0
            lsm
            jmp .-1

            define
xincr X,Y,INS
            lac Y
            INS sn
            dac Y
            lac Y
            INS scn
            dac X
            term

            define
yincr X,Y,INS
            lac Y
            INS scn
            dac Y
            lac X
            -INS+add+sub sn
            dac X
            terminate

            define
dispatch
            add (. 3
            dap . 1
            jmp .
            term

            define
dispt A,Y,B
            repeat 6  B=B+B
            lio Y
            jda Acb
            xct db1
            term

            define
scale A,B,C
            lac A
            sar B
            dac C
            term
```

```
          define
diff V,S,SF
          add i V
          dac i V
          xct SF
          add i S
          dac i S
          term


          define
random
          lac ran
          rar 1s
          xor (355670
          add (355670
          dac ran
          term

          define
ranct S,SS,C
          random
          S
          SS
          sma
          cma
          dac C
          terminate
```

```
define
        varsft
        dzm xys
        dac t1
        idx xys
v2,     idx xys
        lac t1
        scr 2s
        dac t1
        sza
        jmp v2+R
        scr 2s
        swap
        terminate
define
        undosft
        dac t1
        dio t2
        lac xys
        add sft
        dap .+
        lac .
        dac .+6
        dac .+6
        xor (10000          / changescr to scl or scl to scr.
        dac xyt
        lac t1
        dio t2
        scr .
        scr .
        terminate
define
        integrate A,B
        cli
        lac i A
        scr 9s
        scr 1s
        div t1
        hlt
        cma+cli-opr
        xct xyt
        xct grv
        dac B
        terminate

sft,    lac .-1
        scr 7s
        scr 6s
        scr 5s
        scr 4s
        scr 3s
        scr 2s
        scr 1s
        scr
        scl 1s
```

```
/sine-cosine subroutine.Adams associates
/calling sequence= nurber in AC, jda sin or jdacos.
/argument is between +2 pi, with binary point to right of bit 3.
/answer has binary point to right of bit 0.  Time = 2.35-? ms.
/changed for auto-multiply , ddp 1/19/63

cos,    0
        dap csx
        lac (62210
        add cos
        dac sin
        jmp .+4

sin,    0
        dap csx
        lac sin
        spa
si1,    add (311040
        sub (62210
        sma
        jmp si2
        add (62210

si3,    ral 2s
        mul (242763
        dac sin
        mul sin
        dac cos
        mul (756103
        add (121312
        mul cos
        add (532511
        mul cos
        add (144417
        mul sin
        scl 3s
        dac cos
        xor sin
        sma
        jmp csx-1
        lac (377777
        lio sin
        spl
        cma
        jmp csx

        lac cos
csx,    jmp .

si2,    cma
        add (62210
        sma
        jmp si3
        add (62210
        spa
        jmp .+3
        sub (62210
        jmp si3

        sub (62210
        jmp si1
```

```
/integer square root
/input in ac, binary point to right of bit 17, ida sqt
/answer in ac with binary point between bits 8 and 9
/largest input number = 177777

sqt,    0
        dap sqx
        law i 23
        dac sq1
        dzm sq2
        lio sqt
        dzm sqt

sq3,    isp sq1
        jmp .+3
        lac sq2
sqx,    jmp .

        lac sq2
        sal 1s
        dac sq2
        lac sqt
        rcl 2s
        sza i
        jmp sq3
        dac sqt
        lac sq2
        sal 1s
        add (1
        sub sqt
        sma+sza-skp
        jmp sq3
        spa
        cma
        dac sqt
        idx sq2
        jmp sq3

sq1,    0
sq2,    0
```

```
/outline compiler
/ac=where to compile to  call   jda oc
                                /ot=address of outline table

define
        plinst A
        lac A
        dac i oc
        idx oc
        terminate

define
        contab A, B
        plinst A
        jsp ocs
        lac B
        jmp oce
        terminate

ocs,    dap ocz                 /puts in swap
        dio i oc
        idx oc
ocz,    jmp .

oc,     0                       /outline compiler proper
        dap ocx
        lac i ocx
        dap ocg
        plinst (stf 5
        dap ocm
        idx ocx
ock,    plinst (lac sm1
        plinst (lio sm1
        clf 6
ocj,    setup occ,6
ocg,    lio .                   /outline table
och,    cla
        rcl 3s
        dio oci
        lio (swp                swp=opr 60
        dispatch
        opr
        jmp oc1
oco,    jmp oc2
ocq,    jmp oc3
ocp,    jmp oc4
ocr,    jmp oc5
        jmp oc6
```

```
                plinst (szf 5           / code
                add (4
                dap ocn
                plinst ocn
                plinst (dac sx1
                plinst (dio sy1
                plinst (jmp sc6
                plinst (clf 5
                plinst (lac scm
                plinst (cma
                plinst (dac scm
                plinst (lac ssm
                plinst (cma
                plinst (dac ssm
                plinst (lac csm
                plinst (lio ssd
                plinst (dac ssd
                plinst (dio csm

                plinst (lac sse
                plinst (lio csn
                plinst (dac csn
                plinst (dio sse
                plinst ocm
ocx,            jmp .

ocm,            jmp .
ocn,            jmp .

oc1,            plinst (add sca
                jsp ocs
                lac (sub scn
oce,            dac i oc
                idx oc
                jsp ocs
                plinst (ioh
                lac (rct db2
ocd,            dac i oc
                idx oc
                lio oc1
                count occ, och
                idx ocg
                jmp ocj

oc2,            comtab (add sca, (add sca
oc3,            comtab (add sac, (sub csa
oc4,            comtab (sub sca, (sub sca
oc5,            comtab (add csa, (sub ssd
oc6,            szf 6
                jmp oc9
                stf 6
                plinst (dac sse
                lac (dio sse
                jmp oc4
oc9,            szf 6
                plinst (lac sse
                lac (lio sse
                jmp ocd
```

```
/display gravitational star

define
            starp
            add bx
            swap
            add by
            swap
            ioh
            xct db2
            terminate

blp,        dap blx                     /star
            szs 60
            jmp blx
            random
            rar 9s
            and (400700
            spa
            xor (377777
            dac bx
            lac ran
            ral 4s
            and (400700
            spa
            xor (377777
            dac by
            jsp bpt
            ioh
blx,        jmp .

bpt,        dap bpx
            random
            sar 9s
            sar 6s
            spa
            cma
            sal 3s
            add (bds
            dap bjm
            clf 6
bjl,        cla cli-opr
            szf 4
            jmp bjq
            sub ny1 1
            swp
            sub nx1 1
            jmp bjm-1
bjq,        sub ny1
            swp
            sub nx1
            xct db2
bjm,        jmp .
bds,        repeat 10, starp
            szf 6
bpx,        jmp .
            stf 6
            lac bx
            cma
            dac bx
```

```
/background display - 2/12/69 - jms.

        define
dislis J, 0
        dap frr+R
        clf 5
        lac flo+R
        dap fpo+R
fs,     dap fin+R
        dap fyn+R
        idx fyn+R

fin,    lac         /lac Y
        sub fpo     /right margin
        sma
        sub (20000
        add (2000
frr,    spq
fou,    jmp fuu+R
fie,    sub (1000
        sal 8s
fyn,    lio         /lio Y
        jda keb
        xct db1
        stf 5
fid,    idx fyn+R
        sad (lio 0+2
        jmp flp+R
        sad fpo+R
        jmp fx+R
        dap fin+R
        idx fyn+R
        jmp fin+R

fuu,    szf 5
fx,     jmp         /return
        idx flo+R
        idx flo+R
        sas (0+2
        jmp fid+R
        law J
        dac flo+R
        jmp fid+R

flp,    lac (lio J
        sad fpo+R
        jmp fx+R
        dap fin+R
        law J+
        dam fyn+R
        jmp fin+R

fpo,    lio
flo,    J
        terminate
```

```
            define
background
            jsp bck
            termin

bck,        dap bcx
            sza 40
            jmp bcx
            jsp 1m
            jsp 2m
            idx bcc
            and (1
            sza
            jsp 3m
bc1,        law 3
            and bcc
            sza 1
            jsp 4m
bc3,        isp bkc
            jmp bcy
            law i 10
            dac bkc
            law i 1
            add fpr
            spa
            add (20000
            dac fpr
bcy,        jsp 1m
bcx,        jmp

1m,         dislis 1j, 1c
2m,         dislis 2j, 2c
3m,         dislis 3j, 3c
4m,         dislis 4j, 4c

bcc,        0
bkc,        0
fpr,        10000
```

```
mul=mus
div=dis

start
```

```
/main control routine for spaceships

nob=30                          /total number of colliding objects

ml0,    setup mtc, 5000         /delay for loop
        init ml1, mtb           /loc of calc routines
        add (nob
        dap mx1                 / x
nx1=mtb nob
        add (nob
        dap my1                 / y
ny1=nx1 nob
        add (nob
        dap ma1                 / count for length of explosion or torp
na1=ny1 nob
        add (nob
        dap mb1                 / count of instructions taken by calc routine
nb1=na1 nob
        add (nob
        dac mdx                 / dx
ndx=nb1 nob
        add (nob
        dac mdy                 / dy
ndy=ndx nob
        add (nob
        dap mom                 /angular velocity
nom=ndy nob
        add (2
        dap mth                 / angle
nth=nom 2
        add (2
        dac mfu                 /fuel
nfu=nth 2
        add (2
        dac mtr                 / no torps remaining
ntr=nfu 2
        add (2
        dap mot                 / outline of spaceship
not=ntr 2
        add (2
        dap mco                 / old control word
nco=not 2
        add (2
        dac mh1
nh1=nco 2
        add (2
        dac mh2
nh2=nh1 2
        add (2
        dac mh3
nh3=nh2 2
        add (2
        dac mh4
nh4=nh3 2
nnn=nh4 2
```

```
4       szf 4
        jmp . 4
        law dj6
        stf 4
        jmp . 3
        law dj5
        clf 4
        dap . 1
        lac .
        dac db1
        idx .-2
        xct .-3
        dac db2

        law ss1
        xor mtb
        sza
        jmp mdn
        law ss2
        xor mtb 1
        sza
        jmp mdn
        law 1       / test if both ships out of torps
        add ntr
        spa
        jmp md1
        law 1
        add ntr 1
        spa
        jmp mdn
md1,    xct tlf     / restart delay is 2X torpedo life
        sal 1s
        dac ntd
        jmp ml1

mdn,    count ntd,ml1
        stf 1
        stf 2
        law ss1
        xor mtb
        sza
        clf 1
        sza 1
        idx 1sc
        law ss2
        xor mtb 1
        sza
        clf 2
        sza 1
        idx 2sc
        clf 2
        jmp a
db1,    0
db2,    0
dj5,    dpy-1
        dpy-4000
dj6,    dpy-1 400
        dpy-4000 400
```

```
a1,     law mg2                 / test word control
        dac cwg
        jmp a

a40,    law cwr     / here from start at 4
        dac cwg
        jmp a6

1sc,    0           /scores
2sc,    0

a,      lac gct
        sma
        jmp a5
        count gct, a5
        lac 1sc
        sas 2sc
        jmp a4
        lac f1u
        sad (jmp 4
        jmp a4
        law i1
        dac gct
a5,     lat
        and (40
        sza i
        jmp a2
a4,     jmp f11
        lat
        and (40
        sza
        jmp a2
        dzm 1sc
        dzm 2sc
a6,     lat
        rar 6s
        and (37
        sza
        cma
        dac gct
a2,     clear mtb, nnn-1    / clear out all tables
        law ss1
        dac mtb
        law ss2
        dac mtb 1
        lac (200000
        dac mx1
        dac my1
        cma
        dac mx1 1
        dac my1 1
        lac (144420
        dac mth
```

```
        law nnn     / start of outline program
        dac not
        lio ddd
        spi i
        jmp a3
        jda oc              / compile outline
        ot1
a3,     dac not 1
        dap fi1
        jda oc
        ot2
        dap fi2
        xct tno
        dac ntr
        dac ntr 1
        lac foo
        dac nfu
        dac nfu+1
        law 2000
        dac nb1
        dac nb1 1
        xct nhs
        dac nh2
        dac nh2 1
        jmp m10
```

```
/ cotrol word get routines

mg1,    dap mg3
        cli
        iot 11
        rir 4s
mg3,    jmp .

mg2,    dap mg4
        lat
        swap
mg4,    jmp .

idl,    idx mth
        idx mfu
        idx mtr
        idx mco
        idx mot
        idx mom
        idx mh1
        idx mh2
        idx mh3
        idx mh4
ids,    idx mx1
        idx my1
        idx ma1
        idx mb1
        idx mdy
        idx mdx
ml1,    lac .                   / 1st control word
        sza i                   / zero if not active
        jmp mc1                 / not active
        dap . 1
        jmp .
mb1,    lac .                   / alter count of number of instructions
        add mtc
        dac mtc
mc1,    idx ml1
        sad (lac mtb 1
        jmp idl
        sas (lac mtb nob
        jmp ids
        background
        jsp blp                 / display massive star
        count mtc, .            / use up rest of time of main loop
        jmp ml0                 / repeat whole works
```

```
col,    dap cox
        law 1
        add ml1
        sad (lac mtb nob
        jmp cox-1
        dap ml2
        law 1
        add mx1
        dap mx2
        law 1
        add my1
        dap my2
        law 1
        add ma1
        dap ma2
        law 1
        add mb1
        dap mb2
ml2,    lac .                   / 2nd control word
        spq         / can it collide?
        jmp mq2                 / no
mx1,    lac .                   / calc if coll'sion
mx2,    sub .                   / delta x
        spa                     / take abs val
        cma
        dac mt1
        sub me1                 / < EPSILON ?
        sma
        jmp mq2                 / no
my1,    lac .
my2,    sub .
        spa
        cma
        sub me1                 / < epsilon ?
        sma
        jmp mq2                 / no
        add mt1
        sub me2
        spa
        jmp cox
mq2,    idx mx2                 / end of comparison loop
        idx my2
        idx ma2
        idx mb2
        index ml2, (lac mtb nob, ml2
        idx cox
cox,    jmp .
```

```
/routine to set explosion

            law 20
            dac i mb1
            dac i mb2
sex,        lac (nex 400000         /EXPLODE
            dac i ml1               / replace calc routine with explosion
            dac i ml2
            lac i mb1               / duration of explosion
mb2,        add .
            cma
            sar 8s
            add (1
ma1,        dac .
ma2,        dac .

/ misc calculation routines

            / explosion

mex,        lac i mdx
            sar 3s
            add i mx1
            dac i mx1
            lac i mdy
            sar 3s
            add i my1
            dac i my1
            law mst
            dap msh
            lac i mb1               / time involved
            cma cli-opr
            sar 3s
            dac mxc
            sub (140
            sma
            idx msh
mz1,        lac ran
            and (777
            ior (sc1
            dac mi1
            randor
            scr 9s
            sir 9s
msh,        xct .
mi1,        hlt
            add i my1
            swap
            add i mx1
            jda kcb
            xct db1
            count mxc, mz1
            count i ma , mb1
            dzm i ml1
            jmp mb1

mst,        scr 1s
            scr 3s
```

```
/ torpedo calc routine

tcr,        jsp col
            jmp sex-3
            count i ma1, tc1
            lac (mex 400000
            dac i ml1
            law i 2
            dac i ma1
            law 20
            dac i mb1
            jmp mb1

tc1,        lac i mx1
            sar 9s
            xct the
            add i mdy
            dac i mdy
            sar 3s
            add i my1
            dac i my1
            sar 9s
            xct the
            add i mdx
            dac i mdx
            sar 3s
            add i mx1
            dac i mx1
            dispt i, i my1, 1
            jmp mb1

/ hyperspace routines

/ this routine handles a non-colliding ship invisibly
/ in hyperspace

hp1,        count i ma1, mb1
            law hp3                 / next step
            dac i ml1
            law 7
            dac i mb1
            random
            scr 9s
            sir 9s
            xct hr1
            add i mx1
            dac i mx1
            swap
            add i my1
            dac i my1
            dzm i mdx
            dzm i mdy
            xct hr2
            dac i ma1
            jmp mb1
```

```
/ this routine handles a ship breaking out of
/ hyperspace.

hp3,    jsp col
        jmp sex
        count i ma1,hp6
        law 2000
        dac i mb1
        lac i mh4
        add hur
        dac i mh4
        random
        ior (400000
        add i mh4
        sma
        jmp po1
        lac i mh1
        dac i ml1
        lac ran
        scr 9s
        sir 9s
        xct hr2
        dac i mdy
        dio i mdx
        setup hpt,3
        lac ran
        sar 6s
        dac i mom
        lac ran
        dac i mth
hp4,    lac i mth
        sma
        sub (311040
        spa
        add (311040
        dac i mth
        count hpt,hp4
        count i mh2,hp7
        dzm i mh2
hp7,    xct hd3
        dac i mh3
hp6,    lac i mx1
        dispt i  i my1, 2
        jmp rb1


kcb.    0                       /relocate for center display
        dap kc1
        lac kcb
        szf 4
        jmp . 6
        sub mx1 1
        swap
        sub my1 1
        swap
        jmp kc1
        sub mx1
        swap
        sub my1
        swap
kc1.    jmp .
```

```
/ spaceship calc
ss1,        jsp i cwg
            dio scw
            jmp sr0

ss2,        jsp i cwg
            rir 4s
            dio scw

sr0,
sc1,        clf 6
            jsp col
            jmp scx
            lio scw
            clf 6 cla-opr          /update angle
            spi
            add maa
            ril 1s
            spi
            sub maa
mom,        add .
            dac i mom
            szs 10
            jmp . 3
            dzm i mom
            ral 7s
            ril 1s
            spi
            stf 6
            lio i mfu
            spi i
            clf 6

mth,        add .
            sma
            sub (311040
            spa
            add (311040
            dac i mth
            jda sin
            dac sn
            dzm bx
            dzm by
            szs 60
            jmp bsg
            lac i mx1
            dac t1
            mul t1
            scr 1s
            dac acx
            cla
            scr 2s
            dio iox
            lac i my1
            dac t1
            mul t1
            scr 1s
            dac acy
```

```
        cla
        scr 2s
        swap
        add iox
        swap
        scl 2s
        add acx
        add acy
        sub str
        sma i sza-skp
        jmp pof
        add str
        varsft
        dac t1
        jda sqt
        mul t1
        undosft
        scr 9s
        scr 8s
        sza
        jmp bsg
        scr 1s
        dio t1
        integrate mx1, bx
        integrate my1, by
bsg,    lac i mth
        jda cos
        dac cs
        sar 9s
        xct sac
        szf i 6
        cla
        add by
        diff mdy, my1, (sar 3s
        lac sn
        sar 9s
        xct sac
        cma
        szf i 6
        cla
        add bx
        diff mdx, mx1, (sar 3s
        scale sn, 5s, ssn
        scale cs, 5s, scn
        lac i mx1
        szf 4
        sub nx1
        szf i 4
        sub nx1 1
        sub ssn
        dac sx1
        sub ssn
        dac stx
```

```
            lac i my1
            szf 4
            sub ny1
            szf i 4
            sub ny1 1
            add scn
            dac sy1
            add scn
            dac sty
            scale sn, 9s, ssn
            scale cs, 9s, scn
            dac scm
            lac ssn
            dac ssm
            add scn
            dac ssc
            dac ssd
            lac ssn
            sub scn
            dac csn
            cma
            dac csm
            cla cli-opr
            jda kcb
            xct db2
mot,sp5,    jmp i .
sq6,        ioh
            llo scw
            ril 2s
            spi i                   / not blasting
            jmp sq9                 / no tail
            ranct scr 9s, scr 8s, src
            scale sn, 8s, ssn
            scale cs, 8s, scn
sq7,        count i mfu, st2
            dzm i mfu
            jmp sq9
```

```
st2,    yincr sx1, sy1, sub
        lio sy1
        rct db1
        count src,sc7
sc9,    count 1 ma1, sr5        / check if torp tube reloaded
        dzm 1 ma1               / prevent count around
mco,    lac .                   / previous control word
        cma
        szs 1 30
        clc
        and scw    / present control word
        ral 3s                  / torpedo bit to bit 0
        sma
        jmp sr5                 / no launch
        count 1 mtr, st1        / check if torpedos exhausted
        dzm 1 mtr                       /prevent count around
        jmp sr5
st1,    init sr1, mtb nob-1             /search for unused object
sr1,    lac .
        sza 1                   / 0 if unused
        jmp sr2
        law 1 1
        add sr1
        dap sr1
        sas (lac mtb-1
        jmp sr1
        jmp sr5                 / no space for new objects

sr2,    lac (tcr                / set up torpedo calc
        dac 1 sr1
        law nob
        add sr1
        dap ss3
        lio stx
        swp
        szf 4
        add nx1
        szf 1 4
        add nx1 1
        swp
ss3,    dio .
        add (nob
        dap ss4
        lio sty
        swp
        szf 4
        add ny1
        szf 1 4
        add ny1 1
        swp
ss4,    dio .
```

```
        add (nob
        dap sr6
        add (nob
        dap sr7
        add (nob
        dap sr3
        add (nob
        dap sr4
        lac sn
        xct tvl
        cma
        add i mdx
sr3,    dac .
        lac cs
        xct tvl
        add i mdy
sr4,    dac .
        xct rlt
        dac i ma1               / permit torp tubes to cool
        xct tlf   / life of torpedo
sr6,    dac .
        lac (lac mtb nob-1
        sub sr1
        sal 3s
        add (30
sr7,    dap .                   / length of torp calc.
sr5,    lac scw
        dac i mco
        count i mh3, mb1
        dzm i mh3
        lac i mh2
        sza i
        jmp mb1
        lac scw
        and (600000
        xor (600000
        sza
        jmp mb1
        lac i ml1
        dac i mh1
        lac (hp1 400000
        dac i  ml1
        xct hd1
        dac i ma1
        law 2
        dac i mb1
        jmp mb1
```

```
/ here to handle spaceships dragged into star

/ spaceship in star

pof,    dzm i mdx
        dzm i mdy
        szs 50
        jmp po1
        lac (377777
        dac i mx1
        dac i my1
        lac i mb1
        dac ssn
        count ssn, .
        jmp mb1

po1,    lac (mox 400000      / now go bang
        dac i ml1
        law i 10
        dac i ma1
        jmp mb1

/ outlines of spaceships

ot1,    111131
        111 11
        111111
        11 163
        31 111
        146111
        111114
        700000
. 5/

ot2,    013113
        1131 1
        116313
        1311 1
        161151
        111633
        365114
        700000
. 5/


        variables
        constants


.-60/
p,      . 100/              / space for patches
```

```
/display score rout'ne

fss,    0           /set size of spaceship
        dap fs1
        lac fss
        dac scm
        dac ssc
        dac ssd
        dac scn
        dac csm
        cma
        dac csn
        dzm ssn
        dzm ssm
fs1,    jmp .

fi1,    law .       /set return of compiled outline
        sub c21
        dac t6
fi2,    law .
        sub c21
        dac t7
fis,    lac c23
        dac t4
        szf 3
        lio 2sc     /get score
        szf 3
        lio 1sc
        scl 1s
        cla
        div c12
        hlt
        sza
        jmp fx1
fkr,    dic t3
        law 400
        jda fss
        law fys
        dap frt
flt,    idx t3
        cma
        dac t3
        law fus
        dap i t6
        dap i t7
fus,    lac c20
        szf 3
        cma
        dac sy1
        lac t4
        add c20
        dac t4
        dac sx1
```

```
fds,    szf 3       /display spaceship
        law not
        szf i 3
        law not 1
        dap fug
        idx t5
        ral 9s
        cli
        xct db2
        isp t3
fug,    jmp i .
frt,    jmp .

fys,    law 4000
        jda fss
        law fub
        dap i t6
        dap i t7
        lac c26
        dac sx1
        lac c20
        szf i 3
        cma
        add c30
        dac sy1
        law i 2
        dac t3
        jmp fds
fub,    szf 3
        jmp . 3
        stf 3
        jmp . 2
        clf 3
        cli
        iot 11
        dio t1
        law 21
        xor t1
        sza i
        jmp fik
        law 42
        xor t1
        sza
        jmp fkg
        law a4+
        jmp fwt-1
fik,    law 4
        dap fiu
fwt,    add .
        dac .+1
        isp t1
        jmp .-1
fiu,    jmp .
```

```
fx1,        dio t1
            dac t3
            law fx2
            dap frt
            law 1100
            jda fss
            jmp flt
fx2,        lio t1
            jmp fkr

fkg,        szf 3
            jmp fis
            szf 4
            jmp . 4
            law dj6
            stf 4
            jmp . 3
            law dj5
            clf 4
            dap . 1
            lac .
            dac db1
            idx .-2
            xct .-3
            dac db2
            jmp fis

c12,        12
c20,        200000
c21,        21
c23,        -200000-30000
c26,        -260000
c30,        30000
t3,         0
t4,         0
t5,         0
t6,         0
t7,         0

mtb,                    / table of objects and their properties


start 4
```

```
spacewar 4.4  5/17/63  ddp  : pt 1 - pass 1
spacewar 4.4  5/21/63  ddp  : pt 2 - pass 1
stars by prs  for s/w 2b - pass 1
foo
nx1=mtb nob
ny1=nx1 nob
start
foo - pass 1
spacewar 4.4  5/17/63  ddp  : pt 1 - pass 2
spacewar 4.4  5/21/63  ddp  : pt 2 - pass 2
usw      1362       a+13       count      i1
stars by prs  for s/w 2b - pass 2
spacewar 4.4 syms   5/23/63   jcm

Constants area, inclusive
from     to
2736     3063
```

1j	6077
1m	706
1q	6117
1sc	1345
2j	6121
2m	764
2q	6141
2sc	1346
3j	6143
3m	1042
3q	6403
4j	6405
4m	1120
4q	7747
a	1347
a1	1337
a2	1405
a3	1436
a4	1370
a40	1342
a5	1364
a6	1377
acx	2727
acy	2731
bc1	667
bc3	673
bcc	1176
bck	656
bcx	705
bcy	704
bds	544
bjl	530
bjm	543
bjq	537
bkc	1177
blp	464
blx	511
bpt	512
bpx	645
bsg	2275
bx	2704
by	2705
c12	3407
c21	3411
c23	3412
c26	3413
c20	3410
c30	3414
col	1534
cos	100
cox	1614
cs	2732
csm	2676
csn	2701

csx	146
cwg	2720
cwr	40
db1	1331
db2	1332
ddd	20
dj5	1333
dj6	1335
fds	3272
fi1	3225
fi2	3230
fid	24
fie	16
fik	3347
fin	7
fis	3233
fiu	3355
fkg	3367
fkr	3247
flo	55
flp	45
flt	3254
foo	12
fou	15
fpo	54
fpr	1200
frr	14
frt	3305
fs	4
fs1	3224
fss	3210
fub	3325
fug	3304
fus	3262
fuu	34
fwt	3351
fx	35
fx1	3356
fx2	3365
fyn	20
fys	3306
gct	2721
grv	32
hd1	23
hd2	24
hd3	25
hp1	1744
hp3	1775
hp4	2036
hp6	2053
hp7	2051
hpt	2724
hr1	26
hr2	27

hur	30
idl	1472
ids	1504
iox	2730
kc1	2102
kcb	2060
ma1	1630
ma2	1631
maa	13
mb1	1517
mb2	1624
mco	2451
md1	1303
mdn	1307
mdx	2707
mdy	2710
me1	16
me2	17
mex	1632
mfu	2711
mg1	1460
mg2	1465
mg3	1464
mg4	1471
mh1	2713
mh2	2714
mh3	2715
mh4	2716
mhs	2
mi1	1667
ml1	1512
ml2	1556
ml0	1201
mom	2123
mot	2402
mq1	1522
mq2	1604
msh	1666
mst	1704
mt1	2722
mtb	3422
mtc	2706
mth	2137
mtr	2712
mx1	1561
mx2	1562
mxc	2723
my1	1571
my2	1572
mz1	1653
na1	3532
nb1	3562
nco	3704
ndx	3612

ndy	3642
nfu	3676
nh1	3706
nh2	3710
nh3	3712
nh4	3714
nnn	3716
nob	30
nom	3672
not	3702
ntd	2717
nth	3674
ntr	3700
nx1	3452
ny1	3502
oc	226
oc1	373
oc2	416
oc3	424
oc4	432
oc5	440
oc6	446
oc9	456
occ	2672
ocd	407
oce	400
ocg	250
och	251
oci	2673
ocj	246
ock	237
ocm	371
ocn	372
oco	262
ocp	264
ocq	263
ocr	265
ocs	222
ocx	370
ocz	225
ot1	2630
ot2	2645
p	3110
po1	2623
pof	2607
ran	31
rlt	10
sac	14
sbf	61
sc1	2111
scm	2674
scn	2663
scw	2725
sex	1620

sft	66
si1	112
si2	147
si3	117
sin	106
sn	2726
sp5	2402
sq1	220
sq2	221
sq3	171
sq6	2403
sq7	2430
sq9	2446
sqt	162
sqx	174
sr1	2467
sr2	2500
sr3	2543
sr4	2547
sr5	2561
sr6	2553
sr7	2560
src	2735
sr0	2111
ss1	2103
ss2	2106
ss3	2514
ss4	2526
ssa	2702
ssc	2700
ssd	2677
ssi	2703
ssm	2675
ssn	2662
st1	2465
st2	2434
str	15
stx	2733
sty	2734
sx1	2670
sy1	2671
t1	2665
t2	2666
t3	3415
t4	3416
t5	3417
t6	3420
t7	3421
tc1	1721
tcr	1706
the	21
tlf	11
tno	6
tvl	7

v2	3
xys	2664
xyt	2667

```
3/      jmp sbf                 / ignore sec. break
        jmp a40
        jmp a1      / use test word for control, not iot 11 co

/ interesting and often changed constants

/symb loc   usual value (all instructions are executed,
          / and may be replaced by jda or jsp)

tno,  6,   law i 41             / number of torps + 1
tvl,  7,   sar 4s       / torpedo velocity
rlt, 10,   law i 20     / torpedo reload time
tlf, 11,   law i 140            / torpedo life
foo, 12,   -20000       / fuel supply
maa, 13,   10           / spaceship angular acceleration
sac, 14,   sar 4s       / spaceship acceleration
str, 15,   100          / star capture radius
me1, 16,   6000         / collision "radius"
me2, 17,   3000         / above/2
ddd, 20,   -0           / 0 to save space for ddt
the, 21,   sar 9s       / amount of torpedo space warpage
mhs, 22,   law i 10     / number of hyperspace shots
hd1, 23,   law i 40     / time in hyperspace before breakout
hd2, 24,   law i 100            / time in hyperspace breakout
hd3, 25,   law i 200            / time to recharge hyperfield generators
hr1, 26,   scl 9s       / scale on hyperspatial displacement
hr2, 27,   scl 4s       / scale on hyperspatially induced velocity
hur, 30,   40000        / hyperspatial uncertancy
ran, 31,   0            / random number
grv, 32,   sar 6s       / gravitational constant

/ place to build a private control word routine.
/ it should leave the control word in the io as follows.
/ high order 4 bits, rotate ccw, rotate cw, (both mean hyperspace)
/    fire rocket, and fire torpedo. Low order 4 bits, same for
/    other ship.  Routine is entered by jsp cwg.

40/

cwr,    jmp mg1     / normally iot 11 control
. 20/   / space
```

```
/ routine to flush sequence breakes, if they occur.

sbf,        tyi
            lio 2
            lac 0
            lsm
            jmp i 1

            define
xincr X,Y,INS
            lac Y
            INS ssn
            dac Y
            lac X
            INS scn
            dac X
            term

            define
yincr X,Y,INS
            lac Y
            INS scn
            dac Y
            lac X
            -INS+add+sub ssn
            dac X
            terminate

            define
dispatch
            add (. 3
            dap . 1
            jmp .
            term

            define
dispt A,Y,B
            repeat 6  B=B+B
            lio Y
            szs 20
            jda kcb
            dpy-A+B
            term

            define
scale A,B,C
            lac A
            sar B
            dac C
            term
```

```
          define
diff V,S,SF
          add i V
          dac i V
          xct SF
          add i S
          dac i S
          term


          define
random
          lac ran
          rar 1s
          xor (355670
          add (355670
          dac ran
          term

          define
ranct S,SS,C
          random
          S
          SS
          sma
          cma
          dac C
          terminate
```

```
define
        varsft
        dzm xys
        dac t1
        idx xys
v2,     idx xys
        lac t1
        scr 2s
        dac t1
        sza
        jmp v2+R
        scr 2s
        swap
        terminate
define
        undosft
        dac t1
        dio t2
        lac xys
        add sft
        dap .+1
        lac .
        dac .+6
        dac .+6
        xor (10000          / change scr to scl or scl to scr.
        dac xyt
        lac t1
        dio t2
        scr .
        scr .
        terminate
define
        integrate A,B
        cli
        lac A
        scr 9s
        scr 1s
        div t1
        hlt
        cma+cli-opr
        xct xyt
        xct grv
        dac B
        terminate

sft,    lac .-1
        scr 7s
        scr 6s
        scr 5s
        scr 4s
        scr 3s
        scr 2s
        scr 1s
        scr
        scl 1s
```

```
/sine-cosine subroutine•Adams associates
/calling sequence= number in AC, jda sin or jdacos.
/argument is between +2 pi, with binary point to right of bit 3.
/answer has binary point to right of bit 0.  Time = 2.35-? ms.
/changed for auto-multiply , ddp 1/19/63

cos,    0
        dap csx
        lac (62210
        add cos
        dac sin
        jmp .+4

sin,    0
        dap csx
        lac sin
        spa
si1,    add (311040
        sub (62210
        sma
        jmp si2
        add (62210

si3,    rel 2s
        mul (242763
        dac sin
        mul sin
        dac cos
        mul (756103
        add (121312
        mul cos
        add (532511
        mul cos
        add (144417
        mul sin
        scl 3s
        dac cos
        xor sin
        sma
        jmp csx-1
        lac (377777
        lic sin
        spi
        cma
        jmp csx

        lac cos
csx,    jmp .

si2,    cma
        add (62210
        sma
        jmp si3
        add (62210
        spa
        jmp .+3
        sub (62210
        jmp si3

        sub (62210
```

```
/integer square root
/input in ac, binary point to right of bit 17, jda sqt
/answer in ac with binary point between bits 8 and 9
/largest input number = 177777

sqt,    0
        dap sqx
        law i 23
        dac sq1
        dzm sq2
        lio sqt
        dzm sqt

sq3,    isp sq1
        jmp .+3
        lac sq2
sqx,    jmp .

        lac sq2
        sal 1s
        dac sq2
        lac sqt
        rcl 2s
        sza i
        jmp sq3
        dac sqt
        lac sq2
        sal 1s
        add (1
        sub sqt
        sma+sza-skp
        jmp sq3
        spa
        cma
        dac sqt
        idx sq2
        jmp sq3

sq1,    0
sq2,    0
```

```
/outline compiler
/ac=where to compile to, call    jda oc
                                 /ot=address of outline table

define
        plinst A
        lac A
        dac i oc
        idx oc
        terminate

define
        comtab A, B
        plinst A
        jsp ocs
        lac B
        jmp oce
        terminate

ocs,    dap ocz                  /puts in swap
        dio i oc
        idx oc
        dio i oc
        idx oc
ocz,    jmp .

oc,     0                        /outline compiler proper
        dap ocx
        lac i ocx
        dap ocg
        plinst (stf 5
        dap ocm
        idx ocx
ock,    plinst (lac sx1
        plinst (lio sy1
        clf 6
ocj,    setup occ,6
ocg,    lio . .                  /outline table
och,    cla
        rcl 3s
        dio oci
        lio (rcl 9s
        dispatch
        opr
        jmp oc1
oco,    jmp oc2
ocq,    jmp oc3
ocp,    jmp oc4
ocr,    jmp oc5
        jmp oc6
```

```
                plinst (szf 5           /7 code
                add (4
                dap ocn
                plinst ocn
                plinst (dac sx1
                plinst (dio sy1
                plinst (jmp sq6
                plinst (clf 5
                plinst (lac scm
                plinst (cma
                plinst (dac scm
                plinst (lac ssm
                plinst (cma
                plinst (dac ssm
                plinst (lac csm
                plinst (lio ssd
                plinst (dac ssd
                plinst (dio csm

                plinst (lac ssc
                plinst (lio csn
                plinst (dac csn
                plinst (dio ssc
                plinst ocm
ocx,            jmp .

ocm,            jmp .
ocn,            jmp .

oc1,            plinst (add ssn
                jsp ocs
                lac (sub scn
oce,            dac i oc
                idx oc
                jsp ocs
                plinst (iob
                lac (dpy-4000
ocd,            dac i oc
                idx oc
                lio oci
                count occ, och
                idx ocg
                jmp ocj

oc2,            comtab (add scm, (add ssm
oc3,            comtab (add ssc, (sub csm
oc4,            comtab (sub scm, (sub ssm
oc5,            comtab (add csn, (sub ssd
oc6,            szf 6
                jmp oc9
                stf 6
                plinst (dac ssa
                lac (dio ssi
                jmp ocd
oc9,            clf 6
                plinst (lac ssa
                lac (lio ssi
                jmp ocd
```

```
/display gravitational star

define
        starp
        add bx
        swap
        add by
        swap
        ioh
        dpy-4000
        terminate

blp,    dap blx                 /star
        szs 60
        jmp blx
        random
        rar 9s
        and (400700
        spa
        xor (377777
        dac bx
        lac ran
        ral 4s
        and (400700
        spa
        xor (377777
        dac by
        jsp bpt
        ioh
blx,    jmp .

bpt,    dap bpr
        random
        sar 9s
        sar 6s
        spa
        cma
        sal 3s
        add (bds
        dap bjm
        cla cli clf 6-cpr-cpr
        szf : 20
        jmp bjm-1
        sub ny1
        swap
        sub nx1
        dpy-4000
bjm,    jmp .
bds,    repeat 10, starp
        szf 6
bpr,    jmp .
        stf 6
        cma
        swap
        cma
        swap
        jmp bjm
```

```
/background display , 3/12/62, rms.

            define
disl's J, 0
            dap fx+R
            clf 5
            lac flo+R
            dap fpo+R
fs,         dap fin+R
            dap fyn+R
            idx fyn+R

fin,        lac         /lac X
            sub fpr     /right margin
            sma
            sub (20000
            add (2000
frr,        spc
fou,        jmp fuu+R
fle,        sub (1000
            sal 8s
fyn,        lic         /lic Y
            szs 20
            jda lcb
            dpy-i
            stf 5
fid,        idx fyn+R
            sad (lio 0+2
            jmp flp+R
            sad fpo+R
            jmp fx+R
            dap fin+R
            idx fyn+R
            jmp fin+R

fuu,        szf 5
fx,         jmp         /return
            idx flo+R
            idx flo+R
            sas (0+2
            jmp fid+R
            law J
            dac flo+R
            jmp fid+R

flp,        lac (lio J
            sad fpo+R
            jmp fx+R
            dap fin+R
            law J+1
            dap fyn+R
            jmp fin+R

fpo,        lio
flo,        J
            terminate
```

```
            define
background
            jsp bck
            termin

bck,        dap bcx
            szs 40
            jmp bcx
            jsp 1m
            jsp 2m
            ldx bcc
            and (1
            szc
            jsp 3m
bc1,        law 3
            and bcc
            sza 1
            jsp 4m
bc3,        isp bkc
            jmp bcy
            law 1 10
            dac bkc
            law 1 1
            add fpr
            spa
            add (20000
            dac fpr
bcy,        jsp 1m
bcx,        jmp

1m,         dislis 10, 1q
2m,         dislis 20, 2q
3m,         dislis 30, 3q
4m,         dislis 40, 4q

bcc,        0
bkc,        0
fpr,        10000
```

```
mul=mus
div=dis

start
```

```
spacewar 4.3  5/17/62  dap  . pt 2

/main control routine for spaceships

nob=30                          /total number of colliding objects

ml0,    setup mtc, 5000         /delay for loop
        init ml1, mtb           /list of calc routines
        add (nob
        dap nx1                 / x
nx1=mtb nob
        add (nob
        dap ny1                 / y
ny1=nx1 nob
        add (nob
        dap ma1                 / count for length of explosion or torp
ma1=ny1 nob
        add (nob
        dap mb1                 / count of instructions taken by calc routine
mb1=ma1 nob
        add (nob
        dac mdx                 / dx
mdx=mb1 nob
        add (nob
        dac mdy                 / dy
mdy=mdx nob
        add (nob
        dap nom                 /angular velocity
nom=mdy nob
        add (2
        dap mth                 / angle
mth=nom 2
        add (2
        dac mfu                 /fuel
mfu=mth 2
        add (2
        dac mtr                 / no torps remaining
mtr=mfu 2
        add (2
        dap mot                 / outline of spaceship
mot=mtr 2
        add (2
        dap mco                 / old control word
mco=mot 2
        add (2
        dac mh1
mh1=mco 2
        add (2
        dac mh2
mh2=mh1 2
        add (2
        dac mh3
mh3=mh2 2
        add (2
        dac mh4
mh4=mh3 2
mnn=mh4 2
```

```
            law ss1
            xor mtb
            sza
            jmp mdn
            law ss2
            xor mtb 1
            sza
            jmp mdn
            law 1       / test if both ships out of torps
            add ntr
            spa
            jmp md1
            law 1
            add ntr 1
            spa 1
            jmp mdn
md1,        rct tlf     / restart delay is 2X torpedo life
            sal 1s
            dac ntf
            jmp ml1

mdn,        count ntd,ml1
            stf 1
            stf 2
            law ss1
            xor mtb
            sza
            clf 1
            sza 1
            idx 1sc
            law ss2
            xor mtb 1
            sza
            clf 2
            sza 2
            idx 2sc
            clf 2
            jmp a
```

```
a1,     law -e2                 / test word control
        dac swc
        jmp .

a40,    law swx     / here from start at 4
        dac swc
        jmp a6

1sc,    0           /scores
2sc,    0

a,      dzm 8j1
        dzm 8j2
        lac cct
        sma
        jmp a5
        scount cct, a5
        lac 1sc
        sas 2sc
        jmp a4
        law 1 1
        dac cct
a5,     lat
        and (40
        sza 1
        jmp a2
a4,     jmp f11
        lat
        and (4c
        sza
        jmp a2
        dzm 1sc
        dzm 2sc
a6,     lat
        rar 6s
        and (37
        sza
        cma
        dac cct
a2,     clear mtb, mmm-1    / clear out all tables
        law ss1
        dac mtb
        law ss2
        dac mtb 1
        lac (200000
        dac mx1
        dac my1
        cma
        dac mx1 1
        dac my1 1
        lac (144420
        dac mth
```

```
        law nnn             / start of outline program
        dac not
        lio ddd
        spi 1
        jmp a3
        jda oc              / compile outline
        ot1
a3,     dac not 1
        dap f11
        jda oc
        ot2
        dap f12
        xct tno
        dac ntr
        dac ntr 1
        lac foo
        dac nfu
        dac nfu+1
        law 2000
        dac nb1
        dac nb1 1
        xct mhs
        dac nh2
        dac nh2 1
        jmp ml0
```

```
/ control word set routines

mg1,    dap .g3
        lot 1
        jsp 8a
8j1,    0
        dac t1
        lot 111
        jsp 8a
8j2,    0
        lac t1
        rtl 4s
        rcr 4s
mg3,    jmp .

mg2,    dap mg4
        lat
        swap
mg4,    jmp .

idl,    idx mth
        idx mfu
        idx mtr
        idx mco
        idx mot
        idx mom
        idx mh1
        idx mh2
        idx mh3
        idx mh4
ids,    idx mx1
        idx my1
        idx ma1
        idx mb1
        idx mdy
        idx mdx
ml1,    lac .                   / 1st control word
        sza i                   / zero if not active
        jmp mq1                 / not active
        dap . 1
        jmp .
mb1,    lac .                   / alter count of number of instructions
        add mtc
        dac mtc
mq1,    idx ml1
        sad (lac mtb 1
        jmp idl
        sas (lac mtb nob
        jmp ids
        background
        jsp blp                 / display massive star
        count mtc, .            / use up rest of time of main loop
        jmp ml0                 / repeat whole works
```

```
8a,     dap 8ay
        dap 8ax
        idx 8ax
        clf 7
        spi
        stf 5
        szf i 5
        stf 6
        nil 1
        spi
        jmp 8ao

8ay,    lac
        rir 8s
        spi
        cla
        rir 1s
        spi
        law 2
        dac i 8ay

8ad,    rir 8s
        spi
        jmp 8ac
        rir 5s
        spi
        ior (14
        rir 1s
        spi
        ior (1
        jmp 8aa

8ao     cla
        rir 9s
        spi
        law 2
        jmp 8ad

8ac,    rir 5s
        spi
        ior (1
        rir 1s
        spi
        ior (14
8aa,    rir 1s
        spi 5
        ior (4
        spi 6
        ior (10
        rir 1s
        spi 5
        ior (10
        spi 6
        ior (4
8ax,    jmp
```

```
col,    dap cox
        law 1
        add ml1
        sad (lac mtb nob
        jmp cox-1
        dap ml2
        law 1
        add mx1
        dap mx2
        law 1
        add my1
        dap my2
        law 1
        add ma1
        dap ma2
        law 1
        add mb1
        dap mb2
ml2,    lac .                   / 2nd control word
        spq         / can it collide?
        jmp mq2                 / no
mx1,    lac .                   / calc if collision
mx2,    sub .                   / delta x
        spa                     / take abs val
        cma
        dac mt1
        sub me1                 / < EPSILON ?
        sma
        jmp mq2                 / no
my1,    lac .
my2,    sub .
        spa
        cma
        sub me1                 / < epsilon ?
        sma
        jmp mq2                 / no
        add mt1
        sub me2
        spa
        jmp cox
mq2,    idx mx2                 / end of comparison loop
        idx my2
        idx ma2
        idx mb2
        index ml2, (lac mtb nob, ml2
        idx cox
cox,    jmp .
```

```
/routine to set explosion

            law 20
            dac i mb1
            dac i mb2
sex,        lac (mex 400000      /EXPLODE
            dac i ml1            / replace calc routine with explosion
            dac i ml2
            lac i mb1            / duration of explosion
mb2,        add .
            cma
            sar 8s
            add (1
ma1,        dac .
ma2,        dac .

/ misc calculation routines

            / explosion

mex,        lac i mdx
            sar 3s
            add i mx1
            dac i mx1
            lac i mdy
            sar 3s
            add i my1
            dac i my1
            law mst
            dap msh
            lac i mb1            / time involved
            cma cli-opr
            sar 3s
            dac mxc
            sub (140
            sma
            idx msh
mz1,        lac ran
            and (777
            ior (sc1
            dac mi1
            random
            scr 9s
            sir 9s
msh,        xct .
mi1,        hlt
            add i my1
            swap
            add i mx1
            szs 20
            jda hcb
            dpy-i 300
            count mxc, mz1
            count i ma1, mb1
            dzm i ml1
            jmp mb1

mst,        scr 1s
            scr 3s
```

```
/ torpedo calc routine

tcr,        jsp col
            jmp sex-3
            count i ma1, tc1
            lac (mex 400000
            dac i ml1
            law i 2
            dac i ma1
            law 20
            dac i mb1
            jmp mb1

tc1,        lac i mx1
            sar 9s
            xct the
            add i mdy
            dac i mdy
            sar 3s
            add i my1
            dac i my1
            sar 9s
            xct the
            add i mdx
            dac i mdx
            sar 3s
            add i mx1
            dac i mx1
            dispt i, i my1, 1
            jmp mb1

/ hyperspace routines

/ this routine handles a non-colliding ship invisibly
/ in hyperspace

hp1,        count i ma1, mb1
            law hp3                 / next step
            dac i ml1
            law 7
            dac i mb1
            random
            scr 9s
            sir 9s
            xct hr1
            add i mx1
            dac i mx1
            swap
            add i my1
            dac i my1
            dzm i mdx
            dzm i mdy
            xct hd2
            dac i ma1
            jmp mb1
```

```
/ this routine handles a ship breaking out of
/ hyperspace.

hp3,    jsp col
        jmp sex
        count i ma1,hp6
        law 2000
        dac i mb1
        lac i mh4
        add hur
        dac i mh4
        random
        ior (400000
        add i mh4
        sma
        jmp po1
        lac i mh1
        dac i ml1
        lac ran
        scr 9s
        sir 9s
        xct hr2
        dac i mdy
        dio i mdx
        setup hpt,3
        lac ran
        sar 6s
        dac i mom
        lac ran
        dac i mth
hp4,    lac i mth
        sma
        sub (311040
        spa
        add (311040
        dac i mth
        count hpt,hp4
        count i mh2,hp7
        dzm i mh2
hp7,    xct hd3
        dac i mh3
hp6,    lac i mx1
        dispt i, i my1, 2
        jmp mb1


kcb,    0                       /relocate for center display
        dap kc1
        swap
        sub my1
        swap
        lac kcb
        sub mx1
kc1,    jmp .
```

```
/ spaceship calc
ss1,        jsp i cwg
            dio scw
            jmp sr0

ss2,        jsp i cwg
            rir 4s
            dio scw

sr0,
sc1,        clf 6
            jsp col
            jmp sex
            lio scw
            clf 6 cla-opr          /update angle
            spi
            add maa
            ril 1s
            spi
            sub maa
mom,        add .
            dac i mom
            szs 10
            jmp . 3
            dzm i mom
            ral 7s
            ril 1s
            spi
            stf 6
            lio i mfu
            spi i
            clf 6

mth,        add .
            sma
            sub (311040
            spa
            add (311040
            dac i mth
            jda sin
            dac sn
            dzm bx
            dzm by
            szs 60
            jmp bsg
            lac i mx1
            dac t1
            mul t1
            scr 1s
            dac acx
            cla
            scr 2s
            dio box
            lac i my1
            dac t1
            mul t1
            scr 1s
            dac acy
```

```
        cla
        scr 2s
        swap
        add ox
        swap
        scl 2s
        add acx
        add acy
        sub str
        sma i sza-skp
        jmp pof
        add str
        varsft
        dac t1
        jda sqt
        mul t1
        undosft
        scr 9s
        scr 8s
        sza
        jmp bsg
        scr 1s
        dio t1
        integrate mx1, bx
        integrate my1, by
bsg,    lac i mth
        jda cos
        dac cs
        sar 9s
        xct sac
        szf i 6
        cla
        add by
        diff mdy, my1, (sar 3s
        lac sn
        sar 9s
        xct sac
        cma
        szf i 6
        cla
        add bx
        diff mdx, mx1, (sar 3s
        scale sn, 5s, ssn
        scale cs, 5s, scn
        lac i mx1
        szs 20
        sub nx1
        sub ssn
        dac sy1
        sub ssn
        dac stx
```

```
            lac i my1
            szs 20
            sub my1
            add scn
            dac sy1
            add scn
            dac sty
            scale sn, 9s, ssn
            scale cs, 9s, scn
            dac scm
            lac ssn
            dac ssm
            add scn
            dac ssc
            dac ssd
            lac ssn
            sub scn
            dac csn
            cma
            dac csm
            cla cli-opr
            szs 20
            jda keb
            dpy-4000
mot,sp5,    jmp i .
sq6,        ioh
            lio scw
            ril 2s
            spi i                   / not blasting
            jmp sq9                 / no tail
            ranct sar 9s, sar 4s, src
            scale sn, 8s, ssn
            scale cs, 8s, scn
sq7,        count i mfu, st2
            dzm i mfu
            jmp sq9
st2,        yincr sx1, sy1, sub
            dispt i  sy1
            count src,sq7
sq9,        count i ma1, sr5        / check if torp tube reloaded
            dzm i ma1               / prevent count around
mco,        lac .                   / previous control word
            cma
            szs i 30
            clc
            and scw   / present control word
            ral 3s                  / torpedo bit to bit 0
            sma
            jmp sr5                 / no launch
            count i mtr, st1        / check if torpedos exhausted
            dzm i mtr                       / prevent count around
            jmp sr5
st1,        init sr1, mtb nob-1             /search for unused object
sr1,        lac .
            sza i                   / 0 if unused
            jmp sr2
            law i 1
            add sr1
            dap sr1
            sas (lac mtb-1
```

```
        jmp sr1
        hlt                     / no space for new objects
        jmp sr5

sr2,    lac (tcr                / set up torpedo calc
        dac i sr1
        law nob
        add sr1
        dap ss3
        lio stx
ss3,    dio .
        add (nob
        dap ss4
        lio sty
ss4,    dio .
        add (nob
        dap sr6
        add (nob
        dap sr7
        add (nob
        dap sr3
        add (nob
        dap sr4
        lac sn
        xct tvl
        cma
        add i mdx
sr3,    dac .
        lac cs
        xct tvl
        add i mdy
sr4,    dac .
        xct rlt
        dac i ma                / permit torp tubes to cool
        xct tlf   / life of torpedo
sr6,    dac .
        lac (lac mtb nob-1
        sub sr1
        sal 3s
        add (30
sr7,    dap .                   / length of torp calc.
sr5,    lac scw
        dac i mco
        count i mh3, mb1
        dzm i mh3
        lac i mh2
        sza i
        jmp mb1
        lac scw
        and (600000
        xor (600000
        sza
        jmp mb1
        lac i ml1
        dac i mh1
        lac (hp1 400000
        dac i  ml1
        xct hd1
        dac i ma1
        law 2
        dac i mb1
```

```
/ here to handle spaceships dragged into star

/ spaceship in star

pof,        dzm i mdx
            dzm i mdy
            szs 50
            jmp po1
            lac (377777
            dac i mx1
            dac i my1
            lac i mb1
            dac ssn
            count ssn, .
            jmp mb1

po1,        lac (nex 400000      / now go bang
            dac i ml1
            law i 10
            dac i ma1
            jmp mb1

/ outlines of spaceships

ot1,        111131
            11111
            111111
            111163
            31 11
            14611
            11114
            700000
. 5/

ot2,        013113
            11311
            116313
            13111
            16151
            111633
            365114
            700000
. 5/


            variables
            constants


.-64/
p,          . 100/              / space for patches
```

```
/display score routine

fss,    0           /set size of spaceship
        dap fs1
        lac fss
        dac scm
        dac ssc
        dac ssd
        dac scn
        dac csm
        cma
        dac csn
        dzm ssn
        dzm csn
fs1,    jmp .

fi1,    law .       /set return of compiled outline
        sub c21
        dac t6
fi2,    law .
        sub c21
        dac t7
fis,    lac c23
        dac t4
        szf 3
        lio 2sc     /get score
        szf i 3
        lio 1sc
        scl 1s
        cla
        div c12
        hlt
        sza
        jmp fx1
fkr,    dio t3
        law 400
        jda fss
        law fys
        dap frt
flt,    idx t3
        cma
        dac t3
        law fus
        dap i t6
        dap i t7
fus,    lac c20
        szf 3
        cma
        dac sy1
        lac t4
        add c30
        dac t4
        dac sx1
```

```
fds,    szf 3       /display spaceship
        law not
        szf i 3
        law not 1
        dap fug
        idx t5
        ral 9s
        clf
        dpy-4000+700
        isp t3
fug,    jmp i .
frt,    jmp .

fys,    law 4000
        jda fss
        law fub
        dap i t6
        dap i t7
        lac c26
        dac sx1
        lac c20
        szf i 3
        cma
        add c30
        dac sy1
        law i 2
        dac t3
        jmp fds
fub,    szf 3
        jmp . 3
        stf 3
        jmp . 2
        clf 3
        iot 11
        dio t1
        iot 111
        dio t2
        law 1
        and t1
        and t2
        sze
        jmp fil
        law 2
        and t1
        and t2
        sza i
        jmp fis
        law a4+
        dap fiu
        jmp fwt
fil,    law 4
        dap fiu
fwt,    add .
        dac t1
        isp t1
        jmp .-1
fiu,    jmp .
```

```
fx1,    dio t1
        dac t3
        law fx2
        dap fxt
        law 1100
        jda fss
        jmp alt
fx2,    lio t1
        jmp @xr

c12,    12
c20,    200000
c21,    21
c23,    -200000-30000
c26,    -260000
c30,    30000
t3,     0
t4,     0
t5,     0
t6,     0
t7,     0

mtb,                / table of objects and their properties

start 4
```

```
spacewar 4.3  5/17/63  ddp  .  pt 1 - pass 1
spacewar 4.3  5/17/63   ddp  . pt 2 - pass 1
stars by prs  for s/w 2b - pass 1
f
nx1=mtb nob
f

nx1=mtb nob
ny1=nx1 nob
start
f - pass 1
spacewar 4.3  5/17/63  ddp  .  pt 1 - pass 2
spacewar 4.3  5/17/63   ddp  . pt 2 - pass 2
stars by prs  for s/w 2b - pass 2
spacewar 4.3 syms   5/23/63   jcm

Constants area, inclusive
from     to
2763     3111
```

1j	6077
1m	704
1q	6117
1sc	1323
2j	6121
2m	763
2q	6141
2sc	1324
3j	6143
3m	1042
3q	6403
4j	6405
4m	1121
4q	7747
8a	1520
8aa	1570
8ad	1543
8ao	1555
8aq	1562
8ax	1602
8ay	1533
8j1	1440
8j2	1444
a	1325
a1	1315
a2	1362
a3	1413
a4	1345
a40	1320
a5	1341
a6	1354
acx	2754
acy	2756
bc1	665
bc3	671
bcc	1200
bck	654
bcx	703
bcy	702
bds	542
bjm	541
bkc	1201
blp	466
blx	513
bpt	514
bpx	643
bsg	2336
bx	2731
by	2732
c12	3423
c21	3425
c23	3426
c26	3427
c20	3424

c30	3430
col	1603
cos	100
cox	1663
cs	2757
csm	2723
csn	2726
csx	146
cwg	2745
cwr	40
ddd	20
fds	3322
fi1	3255
fi2	3260
fid	25
fie	16
fik	3403
fin	7
fis	3263
fiu	3411
fkr	3277
flo	56
flp	46
flt	3304
foo	12
fou	15
fpo	55
fpr	1208
frr	14
frt	3335
fs	4
fs1	3254
fss	3240
fub	3355
fug	3334
fus	3312
fuu	35
fwt	3405
fx	36
fx1	3412
fx2	3421
fyn	20
fys	3336
gct	2746
grv	32
hd1	23
hd2	24
hd3	25
hp1	2015
hp3	2046
hp4	2107
hp6	2124
hp7	2122
hpt	2751

hr1	26
hr2	27
hur	30
id1	1456
ids	1470
iox	2755
kc1	2143
kcb	2132
ma1	1677
ma2	1700
maa	13
mb1	1503
mb2	1673
mco	2511
md1	1267
mdn	1273
mdx	2734
mdy	2735
me1	16
me2	17
mex	1701
mfu	2736
mg1	1435
mg2	1451
mg3	1450
mg4	1455
mh1	2740
mh2	2741
mh3	2742
mh4	2743
mhs	22
mi1	1736
ml1	1476
ml2	1625
ml0	1203
mom	2164
mot	2440
mq1	1506
mq2	1653
msh	1735
mst	1754
mt1	2747
mtb	3436
mtc	2733
mth	2200
mtr	2737
mx1	1630
mx2	1631
mxc	2750
my1	1640
my2	1641
mz1	1722
na1	3546
nb1	3576

nco	3720
ndx	3626
ndy	3656
nfu	3712
nh1	3722
nh2	3724
nh3	3726
nh4	3730
nnn	3732
nob	30
nom	3706
not	3716
ntd	2744
nth	3710
ntr	3714
nx1	3466
ny1	3516
oc	230
oc1	375
oc2	420
oc3	426
oc4	434
oc5	442
oc6	450
oc9	460
occ	2717
ocd	411
oce	402
ocg	252
och	253
oci	2720
ocj	250
ock	241
ocm	373
ocn	374
oco	264
ocp	266
ocq	265
ocr	267
ocs	222
ocx	372
ocz	227
ot1	2655
ot2	2672
p	3140
po1	2650
pof	2634
ran	31
rlt	10
sac	14
sbf	61
sc1	2152
scm	2721
scn	2710

scw	2752
sex	1667
sft	66
si1	112
si2	147
si3	117
sin	106
sn	2753
sp5	2440
sq1	220
sq2	221
sq3	171
sq6	2441
sq7	2466
sq9	2506
sqt	162
sqx	174
sr1	2527
sr2	2541
sr3	2570
sr4	2574
sr5	2606
sr6	2600
sr7	2605
src	2762
sr0	2152
ss1	2144
ss2	2147
ss3	2547
ss4	2553
ssa	2727
ssc	2725
ssd	2724
ssi	2730
ssm	2722
ssn	2707
st1	2525
st2	2472
str	15
stx	2760
sty	2761
sx1	2715
sy1	2716
t1	2712
t2	2713
t3	3431
t4	3432
t5	3433
t6	3434
t7	3435
tc1	1771
tcr	1756
the	21
tlf	11

tno	6
tv1	7
v2	3
xys	2711
xyt	2714

```
spacewar 4.2  5/11/63  ddp .  pt 1

3/          jmp sbf                 / ignore seq. break
            jmp a40
            jmp a1      / use test word for control, not iot 11 co

/ interesting and often changed constants

/symb loc   usual value (all instructions are executed,
          / and may be replaced by jda or jsp)

tno,  6,    law i 41                / number of torps + 1
tvl,  7,    sar 4s      / torpedo velocity
rlt, 10,    law i 20    / torpedo reload time
tlf, 11,    law i 140               / torpedo life
foo, 12,    -20000      / fuel supply
maa, 13,    10          / spaceship angular acceleration
sac, 14,    sar 4s      / spaceship acceleration
str, 15,    100         / star capture radius
me1, 16,    6000        / collision "radius"
me2, 17,    3000        / above/2
ddd, 20,    -0          / 0 to save space for ddt
the, 21,    sar 9s      / amount of torpedo space warpage
mhs, 22,    law i 10    / number of hyperspace shots
hd1, 23,    law i 40    / time in hyperspace before breakout
hd2, 24,    law i 100               / time in hyperspace breakout
hd3, 25,    law i 200               / time to recharge hyperfield generators
hr1, 26,    scl 9s      / scale on hyperspatial displacement
hr2, 27,    scl 4s      / scale on hyperspatially induced velocity
hur, 30,    40000       / hyperspatial uncertancy
ran, 31,    0           / random number
grv, 32,    sar 6s      / gravitational constant

/ place to build a private control word routine.
/ it should leave the control word in the io as follows.
/ high order 4 bits, rotate ccw, rotate cw, (both mean hyperspace)
/    fire rocket, and fire torpedo. Low order 4 bits, same for
/    other ship.  Routine is entered by jsp cwg.

40/

cwr,        jmp mg1     / normally iot 11 control
. 20/       / space
```

```
/ routine to flush sequence breakes, if they occur.

sbf,        tyi
            lio 2
            lac 0
            lsm
            jmp i 1

            define
xincr X,Y,INS
            lac Y
            INS ssn
            dac Y
            lac X
            INS scn
            dac X
            term

            define
yincr X,Y,INS
            lac Y
            INS scn
            dac Y
            lac X
            -INS+add+sub ssn
            dac X
            terminate

            define
dispatch
            add (. 3
            dap . 1
            jmp .
            term

            define
dispt A,Y,B
            repeat 6  B=B+B
            lio Y
            dpy-A+B
            term

            define
scale A,B,C
            lac A
            sar B
            dac C
            term
```

```
          define
diff V,S,SF
          add i V
          dac i V
          xct SF
          add i S
          dac i S
          term


          define
random
          lac ran
          rar 1s
          xor (355670
          add (355670
          dac ran
          term

          define
ranct S,SS,C
          random
          S
          SS
          sma
          cma
          dac C
          terminate
```

```
define
        varsft
        dzm xys
        dac t1
        idx xys
v2,     idx xys
        lac t1
        scr 2s
        dac t1
        sza
        jmp v2+R
        scr 2s
        swap
        terminate
define
        undosft
        dac t1
        dio t2
        lac xys
        add sft
        dap .+1
        lac .
        dac .+6
        dac .+6
        xor (10000          / change scr to scl or scl to scr.
        dac xyt
        lac t1
        dio t2
        scr .
        scr .
        terminate
define
        integrate A,B
        cli
        lac i A
        scr 9s
        scr 1s
        div t1
        hlt
        cma+cli-opr
        xct xyt
        xct grv
        dac B
        terminate

sft,    lac .-1
        scr 7s
        scr 6s
        scr 5s
        scr 4s
        scr 3s
        scr 2s
        scr 1s
        scr
        scl 1s
```

```
/sine-cosine subroutine·Adams associates
/calling sequence= number in AC, jda sin or jdacos.
/argument is between +? pi, with binary point to right of bit 3.
/answer has binary point to right of bit 0.  Time = ?.35-? ms.
/changed for auto-multiply , ddp 1/19/63

cos,    0
        dap csx
        lac (62210
        add cos
        dac sin
        jmp .+4

sin,    0
        dap csx
        lac sin
        spa
si1,    add (311040
        sub (62210
        sma
        jmp si2
        add (62210

si3,    ral 2s
        mul (242763
        dac sin
        mul sin
        dac cos
        mul (756103
        add (121312
        mul cos
        add (532511
        mul cos
        add (144417
        mul sin
        scl 3s
        dac cos
        xor sin
        sma
        jmp csx-1
        lac (377777
        lio sin
        spi
        cma
        jmp csx

        lac cos
csx,    jmp .

si2,    cma
        add (62210
        sma
        jmp si3
        add (62210
        spa
        jmp .+3
        sub (62210
        jmp si3

        sub (62210
        jmp si1
```

```
/integer square root
/input in ac, binary point to right of bit 17, jda sqt
/answer in ac with binary point between bits 8 and 9
/largest input number = 177777

sqt,    0
        dap sqx
        law i 23
        dac sq1
        dzm sq2
        lio sqt
        dzm sqt

sq3,    isp sq1
        jmp .+3
        lac sq2
sqx,    jmp .

        lac sq2
        sal 1s
        dac sq2
        lac sqt
        rcl 2s
        sza i
        jmp sq3
        dac sqt
        lac sq2
        sal 1s
        add (1
        sub sqt
        sma+sza-skp
        jmp sq3
        spa
        cma
        dac sqt
        idx sq2
        jmp sq3

sq1,    0
sq2,    0
```

```
/outline compiler
/ac=where to compile to, call   jda oc
                                /ot=address of outline table

define
        plinst A
        lac A
        dac i oc
        idx oc
        terminate

define
        comtab A, B
        plinst A
        jsp ocs
        lac B
        jmp oce
        terminate

ocs,    dap ocz                 /puts in swap
        dio i oc
        idx oc
        dio i oc
        idx oc
ocz,    jmp .

oc,     0                       /outline compiler proper
        dap ocx
        lac i ocx
        dap ocg
        plinst (stf 5
        dap ocm
        idx ocx
ock,    plinst (lac sx1
        plinst (lio sy1
        clf 6
ocj,    setup occ,6
ocg,    lio .                   /outline table
och,    cla
        rcl 3s
        dio oci
        lio (rcl 9s
        dispatch
        opr
        jmp oc1
oco,    jmp oc2
ocq,    jmp oc3
ocp,    jmp oc4
ocr,    jmp oc5
        jmp oc6
```

```
            plinst (szf 5       /7 code
            add (4
            dap ocn
            plinst ocn
            plinst (dac sx1
            plinst (dio sy1
            plinst (jmp sq6
            plinst (clf 5
            plinst (lac scm
            plinst (cma
            plinst (dac scm
            plinst (lac ssm
            plinst (cma
            plinst (dac ssm
            plinst (lac csm
            plinst (lio ssd
            plinst (dac ssd
            plinst (dio csm

            plinst (lac ssc
            plinst (lio csn
            plinst (dac csn
            plinst (dio ssc
            plinst ocm
ocx,        jmp .

ocm,        jmp .
ocn,        jmp .

oc1,        plinst (add ssn
            jsp ocs
            lac (sub scn
oce,        dac i oc
            idx oc
            jsp ocs
            plinst (ioh
            lac (dpy-4000
ocd,        dac i oc
            idx oc
            lio oci
            count occ, och
            idx ocg
            jmp ocj

oc2,        comtab (add scm, (add ssm
oc3,        comtab (add ssc, (sub csm
oc4,        comtab (sub scm, (sub ssm
oc5,        comtab (add csn, (sub ssd
oc6,        szf 6
            jmp oc9
            stf 6
            plinst (dac ssa
            lac (dio ssi
            jmp ocd
oc9,        clf 6
            plinst (lac ssa
            lac (lio ssi
            jmp ocd
```

```
/display a star

define
        starp
        add bx
        swap
        add by
        swap
        ioh
        dpy-4000
        terminate

blp,    dap blx                 /star
        szs 60
        jmp blx
        random
        rar 9s
        and (400700
        spa
        xor (377777
        dac bx
        lac ran
        ral 4s
        and (400700
        spa
        xor (377777
        dac by
        jsp bpt
        ioh
blx,    jmp .

bpt,    dap bpx
        random
        sar 9s
        sar 6s
        spa
        cma
        sal 3s
        add (bds
        dap bjm
        cla cli clf 6-opr-opr
        dpy-4000
bjm,    jmp .
bds,    repeat 10, starp
        szf 6
bpx,    jmp .
        stf 6
        cma
        swap
        cma
        swap
        jmp bjm
```

```
/background display - 3/13/62, prs.

          define
dislis J, Q
          dap fx+R
          clf 5
          lac flo+R
          dap fpo+R
fs,       dap fin+R
          dap fyn+R
          idx fyn+R

fin,      lac       /lac X
          sub fpr   /right margin
          sma
          sub (20000
          add (2000
frr,      spq
fou,      jmp fuu+R
fie,      sub (1000
          sal 8s
fyn,      lio       /lio Y
          dpy-i
          stf 5
fid,      idx fyn+R
          sad (lio Q+2
          jmp flp+R
          sad fpo+R
          jmp fx+R
          dap fin+R
          idx fyn+R
          jmp fin+R

fuu,      szf 5
fx,       jmp       /return
          idx flo+R
          idx flo+R
          sas (Q+2
          jmp fid+R
          law J
          dac flo+R
          jmp fid+R

flp,      lac (lio J
          sad fpo+R
          jmp fx+R
          dap fin+R
          law J+1
          dap fyn+R
          jmp fin+R

fpo,      lio
flo,      J
          terminate
```

```
            define
background
            jsp bck
            termin

bck,        dap bcx
            szs 40
            jmp bcx
            jsp 1m
            jsp 2m
            idx bcc
            and (1
            sza
            jsp 3m
bc1,        law 3
            and bcc
            sza i
            jsp 4m
bc3,        isp bkc
            jmp bcy
            law i 10
            dac bkc
            law i 1
            add fpr
            spa
            add (20000
            dac fpr
bcy,        jsp 1m
bcx,        jmp

1m,         dislis 1j, 1q
2m,         dislis 2j, 2q
3m,         dislis 3j, 3q
4m,         dislis 4j, 4q

bcc,        0
bkc,        0
fpr,        10000
```

```
mul=mus
div=dis

start
```

```
/main control routine for spaceships

nob=30                          /total number of colliding objects

ml0,    setup mtc, 5000                 /delay for loop
        init ml1, mtb   /loc of calc routines
        add (nob
        dap mx1         / x
nx1=mtb nob
        add (nob
        dap my1         / y
ny1=nx1 nob
        add (nob
        dap ma1         / count for length of explosion or torp
na1=ny1 nob
        add (nob
        dap mb1         / count of instructions taken by calc routine
nb1=na1 nob
        add (nob
        dac mdx         / dx
ndx=nb1 nob
        add (nob
        dac mdy         / dy
ndy=ndx nob
        add (nob
        dap mom         /angular velocity
nom=ndy nob
        add (2
        dap mth         / angle
nth=nom 2
        add (2
        dac mfu         /fuel
nfu=nth 2
        add (2
        dac mtr         / no torps remaining
ntr=nfu 2
        add (2
        dap mot         / outline of spaceship
not=ntr 2
        add (2
        dap mco         / old control word
nco=not 2
        add (2
        dac mh1
nh1=nco 2
        add (2
        dac mh2
nh2=nh1 2
        add (2
        dac mh3
nh3=nh2 2
        add (2
        dac mh4
nh4=nh3 2
nnn=nh4 2
```

```
        law ss1
        xor mtb
        sza
        jmp mdn
        law ss2
        xor mtb 1
        sza
        jmp mdn
        law 1       / test if both ships out of torps
        add ntr
        spa
        jmp md1
        law 1
        add ntr 1
        spa 1
        jmp mdn
md1,    xct tlf     / restart delay is 2X torpedo life
        sal 1s
        dac ntd
        jmp nl1

mdn,    count ntd,nl1
        stf 1
        stf 2
        law ss1
        xor mtb
        sza
        clf 1
        sza i
        idx 1sc
        law ss2
        xor mtb 1
        sza
        clf 2
        sza i
        idx 2sc
        clf 2
        jmp a
```

```
a1,     law mg2         / test word control
        dac swg
        jmp a

a40,    law cwr    / here from start at 4
        dac cwc
        jmp a6

1sc,    0          /scores
2sc,    0

a,      dzm 8j1
        dzm 8j2
        lac get
        sma
        jmp a5
        count get, a5
        lac 1sc
        sas 2sc
        jmp a4
        law i 1
        dac get
a5,     lat
        and (40
        sza i
        jmp a2
a4,     jmp fi1
        lat
        and (40
        sza
        jmp a2
        dzm 1sc
        dzm 2sc
a6,     lat
        rar 6s
        and (37
        sza
        cma
        dac get
a2,     clear mtb, nnr-1            / clear out all tables
        law ss1
        dac mtb
        law ss2
        dac mtb 1
        lac (200000
        dac mx1
        dac my1
        cma
        dac mx1 1
        dac my1 1
        lac (144420
        dac mtb
```

```
        law nnn         / start of outline program
        dac not
        lio ddd
        spf 1
        jmp a3
        jda oc          / compile outline
        ot1
a3,     dac not 1
        dap f11
        jda oc
        ot2
        dap f12
        xct tno
        dac ntn
        dac ntn 1
        lac foo
        dac nfu
        dac nfu+1
        law 2000
        dac nb1
        dac nb1 1
        xct mhs
        dac nh2
        dac nh2 1
        jmp m10
```

```
/ control word get routines

mg1,    dap mg3
        iot 1
        jsp 8a
8j1,    0
        dac t1
        iot 111
        jsp 8a
8j2,    0
        lio t1
        ril 4s
        rcr 4s
mg3,    jmp .

mg2,    dap mg4
        lat
        swap
mg4,    jmp .

id1,    idx mth
        idx mfu
        idx mtr
        idx mco
        idx mot
        idx mom
        idx mh1
        idx mh2
        idx mh3
        idx mh4
ids,    idx mx1
        idx my1
        idx ma1
        idx mb1
        idx mdy
        idx mdx
m11,    lac .           / 1st control word
        szn i           / zero if not active
        jmp mq1         / not active
        dap . 1
        jmp .
mb1,    lac .           / alter count of number of instructions
        add mtc
        dac mtc
mq1,    idx m11
        sad (lac mtb 1
        jmp id1
        sas (lac mtb mob
        jmp ids
        background
        jsp blg         / display massive star
        count mtc, .    / use up rest of time of main loop
        jmp m10         / repeat whole works
```

```
8a,     dap 8ay
        dap 8ax
        idx 8ax
        clf 7
        spi
        stf 5
        szf 1 5
        stf 6
        rfl 1
        spi
        jmp 8ao

8ay,    lac
        xir 8s
        spi
        cla
        xir 1s
        spi
        law 2
        dac i 8ay

8ad,    rir 8s
        spi
        jmp 8aq
        xir 5s
        spi
        ion (14
        xir 1s
        spi
        ion (1
        jmp 8aa

8ao,    cla
        xir 9s
        spi
        law 2
        jmp 8ad

8aq,    xir 5s
        spi
        ion (1
        xir 1s
        spi
        ion (14
8ax,    xir 1s
        spi 5
        ion (4
        spi 6
        ion (10
        xir 1s
        spi 5
        ion (10
        spi 6
        ion (4
8ax,    jmp
```

```
col,    dap cox
        law 1
        add ml1
        sad (lac mtb nob
        jmp cox-1
        dap ml2
        law 1
        add mx1
        dap mx2
        law 1
        add my1
        dap my2
        law 1
        add ma1
        dap ma2
        law 1
        add mb1
        dap mb2
ml2,    lac .           / 2nd control word
        spq         / can it collide?
        jmp nq2         / no
mx1,    lac .           / calc if collision
mx2,    sub .           / delta x
        spa             / take abs val
        cma
        dac mt1
        sub me1         / < EPSILON ?
        sma
        jmp nq2         / no
my1,    lac .
my2,    sub .
        spa
        cma
        sub me1         / < epsilon ?
        sma
        jmp nq2         / no
        add mt1
        sub me2
        spa
        jmp cox
nq2,    idx mx2         / end of comparison loop
        idx my2
        idx ma2
        idx mb2
        index ml2, (lac mtb nob, ml2
        idx cox
cox,    jmp .
```

```
/routine to set explosion

        law 2C
        dac i mb1
        dac i mb2
sex,    lac (sex 4CCCCC                 /EXPLODE
        dac i ml1       / replace calc routine with explosion
        dac i ml2
        lac i mb1       / duration of explosion
mb2,    add .
        cma
        sar 8s
        add (1
me1,    dac .
me2,    dac .

/ misc calculation routines

        / explosion

mex,    lac i mdx
        sar 3s
        add i mx1
        dac i mx1
        lac i mdy
        sar 3s
        add i my1
        dac i my1
        law msh
        dap msh
        lac i mb1       / time involved
        cma cli-opr
        sar 3s
        dac mxc
        sub (14C
        sma
        idx msh
mz1,    lac ran
        and (777
        ior (sel
        dac mz1
        random
        scr 9s
        sir 9s
msh,    xct .
mi1,    hlt
        add i my1
        swap
        add i mx1
        dpy-i 300
        count mxc, ms1
        count i me1, mb1
        dzm i ml1
        jmp mb1

ms1,    scr 1s
        scr 3s
```

```
/ torpedo calc routine

tcr,    jsp col
        jmp sex-3
        count i ma1, tc1
        lac (mex 400000
        dac i ml1
        law i 2
        dac i ma1
        law 20
        dac i mb1
        jmp mb1

tc1,    lac i mx1
        sar 9s
        xct the
        add i mdy
        dac i mdy
        sar 3s
        add i my1
        dac i my1
        sar 9s
        xct the
        add i mdx
        dac i mdx
        sar 3s
        add i mx1
        dac i mx1
        dispt 1, i my1, 1
        jmp mb1

/ hyperspace routines

/ this routine handles a non-colliding ship invisibly
/ in hyperspace

hp1,    count i ma1, mb1
        law hp3         / next step
        dac i ml1
        law 7
        dac i mb1
        random
        scr 9s
        sir 9s
        xct hr1
        add i mx1
        dac i mx1
        swap
        add i my1
        dac i my1
        dzm i mdx
        dzm i mdy
        xct hd2
        dac i ma1
        jmp mb1
```

```
/ this routine handles a ship breaking out of
/ hyperspace.

hp3,    jsp col
        jmp sex
        count i ma1,hp6
        law 2000
        dac i mb1
        lac i mh4
        add hur
        dac i mh4
        random
        ior (400000
        add i mh4
        sma
        jmp po1
        lac i mh1
        dac i ml1
        lac ran
        scr 9s
        sir 9s
        xct hr2
        dac i mdy
        dio i mdx
        setup hpt,3
        lac ran
        dac i mth
hp4,    lac i mth
        sma
        sub (311040
        spa
        add (311040
        dac i mth
        count hpt,hp4
        count i mh2,hp7
        dzm i mh2
hp7,    xct hd3
        dac i mh3
hp6,    lac i mx1
        dispt i, i my1, 2
        jmp mb1
```

```
/ spaceship calc
ss1,    jsp i cwg
        dio scw
        jmp sr0

ss2,    jsp i cwg
        rir 4s
        dio scw

sr0,
sc1,    clf 6
        jsp col
        jmp sex
        lio scw
        clf 6 cla-opr  /update angle
        spi
        add maa
        ril 1s
        spi
        sub maa
mom,    add .
        dac i mom
        szs 10
        jmp . 3
        dzm i mom
        ral 7s
        ril 1s
        spi
        stf 6
        lio i mfu
        spi i
        clf 6

mth,    add .
        sma
        sub (311040
        spa
        add (311040
        dac i mth
        jda sin
        dac sn
        dzm bx
        dzm by
        szs 60
        jmp bsg
        lac i mx1
        dac t1
        mul t1
        scr 1s
        dac acx
        cla
        scr 2s
        dio iox
        lac i my1
        dac t1
        mul t1
        scr 1s
        dac acy
```

```
        cla
        scr 2s
        swap
        add iox
        swap
        scl 2s
        add acx
        add acy
        sub str
        sma i sza-skp
        jmp pof
        add str
        varsft
        dac t1
        jda sqt
        mul t1
        undosft
        scr 9s
        scr 6s
        szs i 20        / switch 2 for light star
        scr 2s
        sza
        jmp bsg
        scr 1s
        dio t1
        integrate mx1, bx
        integrate my1, by
bsg,    lac i mth
        jda cos
        dac cs
        sar 9s
        xct sac
        szf i 6
        cla
        add by
        diff mdy, my1, (sar 3s
        lac sn
        sar 9s
        xct sac
        cma
        szf i 6
        cla
        add bx
        diff mdx, mx1, (sar 3s
        scale sn, 5s, ssn
        scale cs, 5s, scn
        lac i mx1
        sub ssn
        dac sx1
        sub ssn
        dac stx
```

```
        lac i my1
        add scn
        dac sy1
        add scn
        dac sty
        scale sn, 9s, ssn
        scale cs, 9s, scn
        dac scm
        lac ssn
        dac ssm
        add scn
        dac ssc
        dac ssd
        lac ssn
        sub scn
        dac csn
        cma
        dac csm
        cla cli-opr
        dpy-4000
mot,sp5,        jmp i .
sq6,    ioh
        lio scw
        ril 2s
        spi i           / not blasting
        jmp sq9         / no tail
        ranct sar 9s, sar 4s, src
        scale sn, 8s, ssn
        scale cs, 8s, scn
sq7,    count i mfu, st2
        dzm i mfu
        jmp sq9
st2,    yincr sx1, sy1, sub
        dispt i, sy1
        count src,sq7
sq9,    count i ma1, sr5            / check if torp tube reloaded
        dzm i ma1       / prevent count around
nco,    lac .           / previous control word
        cma
        szs i 30
        clc
        and scw   / present control word
        ral 3s          / torpedo bit to bit 0
        sma
        jmp sr5         / no launch
        count i mtr, st1            / check if torpedos exhausted
        dzm i mtr                   / prevent count around
        jmp sr5
st1,    init sr1, mtb nob-1         /search for unused object
sr1,    lac .
        sza i           / 0 if unused
        jmp sr2
        law i 1
        add sr1
        dap sr1
        sas (lac mtb-1
        jmp sr1
        hlt             / no space for new objects
        jmp sr5
```

```
sr2,    lac (tcr        / set up torpedo calc
        dac i sr1
        law nob
        add sr1
        dap ss3
        lio stx
ss3,    dio .
        add (nob
        dap ss4
        lio sty
ss4,    dio .
        add (nob
        dap sr6
        add (nob
        dap sr7
        add (nob
        dap sr3
        add (nob
        dap sr4
        lac sn
        xct tvl
        cma
        add i mdx
sr3,    dac .
        lac cs
        xct tvl
        add i mdy
sr4,    dac .
        xct rlt
        dac i ma1       / permit torp tubes to cool
        xct tlf   / life of torpedo
sr6,    dac .
        lac (lac mtb nob-1
        sub sr1
        sal 3s
        add (30
sr7,    dap .           / length of torp calc.
sr5,    lac scw
        dac i mco
        count i mh3, mb1
        dzm i mh3
        lac i mh2
        sza i
        jmp mb1
        lac scw
        and (600000
        xor (600000
        sza
        jmp mb1
        lac i ml1
        dac i mh1
        lac (hp1 400000
        dac i  ml1
        xct hd1
        dac i ma1
        law 2
        dac i mb1
        jmp mb1
```

```
/ here to handle spaceships dragged into star

/ spaceship in star

pof,    dzm i mdx
        dzm i mdy
        szs 50
        jmp po1
        lac (377777
        dac i mx1
        dac i my1
        lac i mb1
        dac ssr
        count ssn, .
        jmp mb1

po1,    lac (mex 400000                 / now go bang
        dac i ml1
        law i 10
        dac i ma1
        jmp mb1

/ outlines of spaceships

ot1,    111131
        111111
        111111
        111163
        31111'
        14611'
        111'14
        700000
. 5/

ot2,    013113
        11311'
        116313
        13111'
        161151
        111633
        3651'4
        700000
. 5/


        variables
        constants

.-64/
p,      . 100/          / space for patches
```

```
/display score routine

fss,    0           /set size of spaceship
        dap fs1
        lac fss
        dac scm
        dac ssc
        dac ssd
        dac scn
        dac csm
        cma
        dac csn
        dzm ssn
        dzm ssm
fs1,    jmp .

fi1,    law .       /set return of compiled outline
        sub c21
        dac t6
fi2,    law .
        sub c21
        dac t7
fis,    lac c23
        dac t4
        szf 3
        lio 2sc     /get score
        szf i 3
        lio 1sc
        scl 1s
        cla
        div c12
        hlt
        sza
        jmp fx1
fkr,    dio t3
        law 400
        jda fss
        law fys
        dap frt
flt     idx t3
        cma
        dac t3
        law fus
        dap i t6
        dap i t7
fus,    lac c20
        szf 3
        cma
        dac sy1
        lac t4
        add c30
        dac t4
        dac sx1
```

```
fds,    szf 3       /display spaceship
        law not
        szf i 3
        law not 1
        dap fug
        idx t5
        ral 9s
        cli
        dpy-4000+700
        isp t3
fug,    jmp i .
frt,    jmp .

fys,    law 4000
        jda fss
        law fub
        dap i t6
        dap i t7
        lac c26
        dac sx1
        lac c20
        szf i 3
        cma
        add c30
        dac sy1
        law i 2
        dac t3
        jmp fds
fub,    szf 3
        jmp . 3
        stf 3
        jmp . 2
        clf 3
        iot 11
        dio t1
        iot 111
        dio t2
        law 1
        and t1
        and t2
        sza
        jmp fik
        law 2
        and t1
        and t2
        sza i
        jmp fis
        law a4+1
        dap fiu
        jmp fwt
fik,    law 4
        dap fiu
fwt,    add .
        dac t1
        isp t1
        jmp .-1
fiu,    jmp .
```

```
fx1,    dio t1
        dac t3
        law fx2
        dap frt
        law 1100
        jda fss
        jmp flt
fx2,    lio t1
        jmp fkr

c12,    12
c20,    200000
c21,    21
c23,    -200000-30000
c26,    -260000
c30,    30000
t3,     0
t4,     0
t5,     0
t6,     0
t7,     0

mtb,                / table of objects and their properties

start 4
```

```
spacewar 4.2  5/11/63  ddp :  pt 1 - pass 1
spacewar 4.2   5/16/63  ddp  : pt 2 - pass 1
stars by prs  for s/w 2b - pass 1
spacewar 4.2  5/11/63  ddp :  pt 1 - pass 2
spacewar 4.2   5/16/63  ddp  : pt 2 - pass 2
stars by prs  for s/w 2b - pass 2
spacewar 4.2 syms   5/2363  jcm

Constants area, inclusive
from     to
2714     3042
```

j	6077
1m	676
1q	6117
1sc	1305
2j	6121
2m	753
2q	6141
2sc	1306
3j	6143
3m	1030
3q	6403
4j	6405
4m	1105
4q	7747
8a	1502
8aa	1552
8ad	1525
8ao	1537
8aq	1544
8ax	1564
8ay	1515
8j1	1422
8j2	1426
a	1307
a1	1277
a2	1344
a3	1375
a4	1327
a40	1302
a5	1323
a6	1336
acx	2705
acy	2707
bc1	657
bc3	663
bcc	1162
bck	646
bcx	675
bcy	674
bds	534
bjm	533
bkc	1163
blp	466
blx	513
bpt	514
bpx	635
bsg	2277
bx	2662
by	2663
c12	3354
c21	3356
c23	3357
c26	3360
c20	3355

c30	3361
col	1565
cos	100
cox	1645
cs	2710
csm	2654
csn	2657
csx	146
cwg	2676
cwr	40
ddd	20
fds	3253
fi1	3206
fi2	3211
fid	23
fie	16
fik	3334
fin	7
fis	3214
fiu	3342
fkr	3230
flo	54
flp	44
flt	3235
foo	12
fou	15
fpo	53
fpr	1164
frr	14
frt	3266
fs	4
fs1	3205
fss	3171
fub	3306
fug	3265
fus	3243
fuu	33
fwt	3336
fx	34
fx1	3343
fx2	3352
fyn	20
fys	3267
gct	2677
grv	32
hd1	23
hd2	24
hd3	25
hp1	1773
hp3	2024
hp4	2062
hp6	2077
hp7	2075
hpt	2702

hr1	26
hr2	27
hur	30
idl	1440
ids	1452
iox	2706
ma1	1661
ma2	1662
maa	13
mb1	1465
mb2	1655
mco	2442
md1	1251
mdn	1255
mdx	2665
mdy	2666
me1	16
me2	17
mex	1663
mfu	2667
mg1	1417
mg2	1433
mg3	1432
mg4	1437
mh1	2671
mh2	2672
mh3	2673
mh4	2674
mhs	22
mi1	1720
ml1	1460
ml2	1607
ml0	1165
mom	2123
mot	2373
mq1	1470
mq2	1635
msh	1717
mst	1734
mt1	2700
mtb	3367
mtc	2664
mth	2137
mtr	2670
mx1	1612
mx2	1613
mxc	2701
my1	1622
my2	1623
mz1	1704
na1	3477
nb1	3527
nco	3651
ndx	3557

ndy	3607
nfu	3643
nh1	3653
nh2	3655
nh3	3657
nh4	3661
nnn	3663
nob	30
nom	3637
not	3647
ntd	2675
nth	3641
ntr	3645
nx1	3417
ny1	3447
oc	230
oc1	375
oc2	420
oc3	426
oc4	434
oc5	442
oc6	450
oc9	460
occ	2650
ocd	411
oce	402
ocg	252
och	253
oci	2651
ocj	250
ock	241
ocm	373
ocn	374
oco	264
ocp	266
ocq	265
ocr	267
ocs	222
ocx	372
ocz	227
ot1	2606
ot2	2623
p	3071
po1	2601
pof	2565
ran	31
rlt	10
sac	14
sbf	61
sc1	2111
scm	2652
scn	2641
scw	2703
sex	1651

sft	66
si1	112
si2	147
si3	117
sin	106
sn	2704
sp5	2373
sq1	220
sq2	221
sq3	171
sq6	2374
sq7	2421
sq9	2437
sqt	162
sqx	174
sr1	2460
sr2	2472
sr3	2521
sr4	2525
sr5	2537
sr6	2531
sr7	2536
src	2713
sr0	2111
ss1	2103
ss2	2106
ss3	2500
ss4	2504
ssa	2660
ssc	2656
ssd	2655
ssi	2661
ssm	2653
ssn	2640
st1	2456
st2	2425
str	15
stx	2711
sty	2712
sx1	2646
sy1	2647
t1	2643
t2	2644
t3	3362
t4	3363
t5	3364
t6	3365
t7	3366
tc1	1751
tcr	1736
the	21
tlf	11
tno	6
tvl	7

v2	3
xys	2642
xyt	2645

```
3/      jmp sbf                         / ignore seq. break
        jmp a40
        jmp a1                  / use test word for control, not iot 11 co

/ interesting and often changed constants

/symb loc   usual value (all instructions are executed,
        / and may be replaced by jda or jsp)

tno,  6,    law i 41        / number of torps + 1
tvl,  7,    sar 4s          / torpedo velocity
rlt, 10,    law i 20        / torpedo reload time
tlf, 11,    law i 140       / torpedo life
foo, 12,    -20000          / fuel supply
maa, 13,    10              / spaceship angular acceleration
sac, 14,    sar 4s          / spaceship acceleration
str, 15,    100             / star capture radius
me1, 16,    6000            / collision "radius"
me2, 17,    3000            / above/2
ddd, 20,    -0              / 0 to save space for ddt
the, 21,    sar 9s          / amount of torpedo space warpage
mhs, 22,    law i 10        / number of hyperspace shots
hd1, 23,    law i 40        / time in hyperspace before breakout
hd2, 24,    law i 100       / time in hyperspace breakout
hd3, 25,    law i 200       / time to recharge hyperfield generators
hr1, 26,    scl 9s          / scale on hyperspatial displacement
hr2, 27,    scl 4s          / scale on hyperspatially induced velocity
hur, 30,    40000           / hyperspatial uncertancy
ran, 31,    0               / random number
grv, 32,    sar 6s          / gravitational constant

/ place to build a private control word routine.
/ it should leave the control word in the io as follows.
/ high order 4 bits, rotate ccw, rotate cw, (both mean hyperspace)
/    fire rocket, and fire torpedo. Low order 4 bits, same for
/    other ship.  Routine is entered by jsp cwg.

40/

cwr,    jmp mg1                 / normally iot 11 control
. 20/   / space
```

```
/ routine to flush sequence breakes, if they occur.

sbf,    tyi
        lio 2
        lac 0
        lsm
        jmp i 1

        define
xincr X,Y,INS
        lac Y
        INS ssn
        dac Y
        lac X
        INS scn
        dac X
        term

        define
yincr X,Y,INS
        lac Y
        INS scn
        dac Y
        lac X
        -INS+add+sub ssn
        dac X
        terminate

        define
dispatch
        add (. 3
        dap . 1
        jmp .
        term

        define
dispt A,Y,B
        repeat 6        B=B+B
        lio Y
        dpy-A+B
        term

        define
scale A,B,C
        lac A
        sar B
        dac C
        term
```

```
        define
diff V,S,SF
        add i V
        dac i V
        xct SF
        add i S
        dac i S
        term


        define
random
        lac ran
        rar 1s
        xor (355670
        add (355670
        dac ran
        term

        define
ranct S,SS,C
        random
        S
        SS
        sma
        cma
        dac C
        terminate
```

```
define
        varsft
        dzm xys
        dac t1
        idx xys
v2,     idx xys
        lac t1
        scr 2s
        dac t1
        sza
        jmp v2+R
        scr 2s
        swap
        terminate
define
        undosft
        dac t1
        dio t2
        lac xys
        add sft
        dap .+1
        lac .
        dac .+6
        dac .+6
        xor (10000    / change scr to scl or scl to scr.
        dac xyt
        lac t1
        dio t2
        scr .
        scr .
        terminate
define
        integrate A,B
        cli
        lac i A
        scr 9s
        scr 1s
        div t1
        hlt
        cma+cli-opr
        xct xyt
        xct grv
        dac B
        terminate

sft,    lac .-1
        scr 7s
        scr 6s
        scr 5s
        scr 4s
        scr 3s
        scr 2s
        scr 1s
        scr
        scl 1s
```

```
/sine-cosine subroutine Adams associates
/calling sequence= number in AC, jda sin or jdacos.
/argument is between +2 pi, with binary point to right of bit 3.
/answer has binary point to right of bit 0.  Time = 2.35-? ms.
/changed for auto-multiply , ddp 1/19/63

cos,    0
        dap csx
        lac (62210
        add cos
        dac sin
        jmp .+4

sin,    0
        dap csx
        lac sin
        spa
si1,    add (311040
        sub (62210
        sma
        jmp si2
        add (62210

si3,    ral 2s
        mul (242763
        dac sin
        mul sin
        dac cos
        mul (756103
        add (121312
        mul cos
        add (532511
        mul cos
        add (144417
        mul sin
        scl 3s
        dac cos
        xor sin
        sma
        jmp csx-1
        lac (377777
        lio sin
        spi
        cma
        jmp csx

        lac cos
csx,    jmp .

si2,    cma
        add (62210
        sma
        jmp si3
        add (62210
        spa
        jmp .+3
        sub (62210
        jmp si3

        sub (62210
        jmp si1
```

```
/integer square root
/input in ac, binary point to right of bit 17, jda sqt
/answer in ac with binary point between bits 8 and 9
/largest input number = 177777

sqt,    0
        dap sqx
        law i 23
        dac sq1
        dzm sq2
        lio sqt
        dzm sqt

sq3,    isp sq1
        jmp .+3
        lac sq2
sqx,    jmp .

        lac sq2
        sal 1s
        dac sq2
        lac sqt
        rcl 2s
        sza i
        jmp sq3
        dac sqt
        lac sq2
        sal 1s
        add (1
        sub sqt
        sma+sza-skp
        jmp sq3
        spa
        cma
        dac sqt
        idx sq2
        jmp sq3

sq1,    0
sq2,    0
```

```
/outline compiler
/ac=where to compile to, call   jda oc
                                /ot=addres of outline table

define
        plinst A
        lac A
        dac i oc
        idx oc
        terminate

define
        comtab A, B
        plinst A
        jsp ocs
        lac B
        jmp oce
        terminate

ocs,    dap ocz                 /puts in swap
        dio i oc
        idx oc
        dio i oc
        idx oc
ocz,    jmp .

oc,     0                       /outline compiler proper
        dap ocx
        lac i ocx
        dap ocg
        plinst (stf 5
        dap ocm
        idx ocx
ock,    plinst (lac sx1
        plinst (lio sy1
        clf 6
ocj,    setup occ,6
ocg,    lio .                   /outline table
och,    cla
        rcl 3s
        dio oci
        lio (rcl 9s
        dispatch
        opr
        jmp oc1
oco,    jmp oc2
ocq,    jmp oc3
ocp,    jmp oc4
ocr,    jmp oc5
        jmp oc6
```

```
        plinst (szf 5       /7 code
        add (4
        dap ocn
        plinst ocn
        plinst (dac sx1
        plinst (dio sy1
        plinst (jmp sq6
        plinst (clf 5
        plinst (lac scm
        plinst (cma
        plinst (dac scm
        plinst (lac ssm
        plinst (cma
        plinst (dac ssm
        plinst (lac csm
        plinst (lio ssd
        plinst (dac ssd
        plinst (dio csm

        plinst (lac ssc
        plinst (lio csn
        plinst (dac csn
        plinst (dio ssc
        plinst ocm
ocx,    jmp .

ocm,    jmp .
ocn,    jmp .

oc1,    plinst (add ssn
        jsp ocs
        lac (sub scn
oce,    dac i oc
        idx oc
        jsp ocs
        plinst (ioh
        lac (dpy-4000
ocd,    dac i oc
        idx oc
        lio oci
        count occ, och
        idx ocg
        mp ocj

oc2,    comtab (add scm, (add ssm
oc3,    comtab (add ssc, (sub csm
oc4,    comtab (sub scm, (sub ssm
oc5,    comtab (add csn, (sub ssd
oc6,    szf 6
        jmp oc9
        stf 6
        plinst (dac ssa
        lac (dio ssi
        jmp ocd
oc9,    clf 6
        plinst (lac ssa
        lac (lio ssi
        jmp ocd
```

```
/display a star

define
        starp
        add bx
        swap
        add by
        swap
        ioh
        dpy-4000
        terminate

blp,    dap blx             /star
        szs 60
        jmp blx
        random
        rar 9s
        and (add 340
        spa
        xor (377777
        dac bx
        lac ran
        ral 4s
        and (add 340
        spa
        xor (377777
        dac by
        jsp bpt
        ioh
blx,    jmp .

bpt,    dap bpx
        random
        sar 9s
        sar 5s
        spa
        cma
        sal 3s
        add (bds
        dap bjm
        cla cli clf 6-opr-opr
        dpy-4000
bjm,    jmp .
bds,    repeat 20, starp
        szf 6
bpx,    jmp .
        stf 6
        cma
        swap
        cma
        swap
        jmp bjm
```

```
/background display • 3/13/62, prs.

        define
dislis J, Q, B
        repeat 6, B=B+B
        clf 5
        lac flo+R
        dap fpo+R
fs,     dap fin+R
        dap fyn+R
        idx fyn+R

fin,    lac             /lac X
        sub fpr         /right margin
        sma
        jmp fgr+R
        add (2000
frr,    spq
fou,    jmp fuu+R
fie,    sub (1000
        sal 8s
fyn,    lio             /lio Y
        dpy-i+B
        stf 5
fid,    idx fyn+R
        sad (lio Q+2
        jmp flp+R
        sad fpo+R
        jmp fx+R
        dap fin+R
        idx fyn+R
        jmp fin+R

fgr,    add (-20000+2000
        jmp frr+R

fuu,    szf 5
fx,     jmp flo+R+1  /return
        idx flo+R
        idx flo+R
        sas (Q+2
        jmp fid+R
        law J
        dac flo+R
        jmp fid+R

flp,    lac (lio J
        sad fpo+R
        jmp fx+R
        dap fin+R
        law J+1
        dap fyn+R
        jmp fin+R

fpo,    lio
flo,    J
        terminate
```

```
        define
background
        jsp bck
        termin

bck,    dap bcx
        szs 40
        jmp bcx
        isp bcc
bcx,    jmp .
        law i 2
        dac bcc
        dislis 1j,1q,3
        dislis 2j,2q,2
        dislis 3j,3q,1
        dislis 4j,4q,0
        isp bkc
        jmp bcx
        law i 20
        dac bkc
        law i 1
        add fpr
        spa
        add (20000
        dac fpr
        jmp bcx

bcc,    0
bkc,    0
fpr,    10000

mul=mus
div=dis

start
```

```
spacewar 4.0   ddp   2/2/63   pt.2

/main control routine for spaceships

nob=30                          /total number of colliding objects

ml0,    load mtc, -4000         /delay for loop
        init ml1, mtb           /loc of calc routines
        add (nob
        dap mx1                 / x
nx1=mtb nob
        add (nob
        dap my1                 / y
ny1=nx1 nob
        add (nob
        dap ma1                 / count for length of explosion or torp
na1=ny1 nob
        add (nob
        dap mb1                 / count of instructions taken by calc routine
nb1=na1 nob
        add (nob
        dac mdx                 / dx
ndx=nb1 nob
        add (nob
        dac mdy                 / dy
ndy=ndx nob
        add (nob
        dap mom                 /angular velocity
nom=ndy nob
        add (2
        dap mth                 / angle
nth=nom 2
        add (2
        dac mfu                 /fuel
nfu=nth 2
        add (2
        dac mtr                 / no torps remaining
ntr=nfu 2
        add (2
        dap mot                 / outline of spaceship
not=ntr 2
        add (2
        dap mco                 / old control word
nco=not 2
        add (2
        dac mh1
nh1=nco 2
        add (2
        dac mh2
nh2=nh1 2
        add (2
        dac mh3
nh3=nh2 2
        add (2
        dac mh4
nh4=nh3 2
nnn=nh4 2
```

```
        law ss1
        xor mtb
        sza
        jmp mdn
        law ss2
        xor mtb 1
        sza
        jmp mdn
        law 1           / test if both ships out of torps
        add ntr
        spa
        jmp md1
        law 1
        add ntr 1
        spa i
        jmp mdn
md1,    xct tlf         / restart delay is 2X torpedo life
        sal 1s
        dac ntd
        jmp ml1

mdn,    count ntd,ml1
        stf 1
        stf 2
        law ss1
        xor mtb
        sza
        clf 1
        sza i
        idx 1sc
        law ss2
        xor mtb 1
        sza
        clf 2
        sza i
        idx 2sc
        clf 2
        jmp a
```

```
a1,     law mg2             / test word control
        dac cwg
        jmp a

a40,    law cwr       / here from start at 4
        dac cwg
        jmp a6

a,      lac gct
        sma
        jmp a5
        count gct, a5
        lac 1sc
        sas 2sc
        jmp a4
        law i 1
        dac gct
a5,     lat
        and (40
        sza i
        jmp a2
a4,     lac 1sc
        lio 2sc
        hlt
        lat
        and (40
        sza
        jmp a2
        dzm 1sc
        dzm 2sc
a6,     lat
        rar 6s
        and (37
        sza
        cma
        dac gct
a2,     clear mtb, nnn-1   / clear out all tables
        law ss1
        dac mtb
        law ss2
        dac mtb 1
        lac (200000
        dac nx1
        dac ny1
        cma
        dac nx1 1
        dac ny1 1
        lac (144420
        dac nth
```

```
        law nnn             / start of outline program
        dac not
        lio ddd
        spi i
        jmp a3
        jda oc              / compile outline
        ot1
a3,     dac not 1
        jda oc
        ot2
        xct tno
        dac ntr
        dac ntr 1
        lac foo
        dac nfu
        dac nfu+1
        law 2000
        dac nb1
        dac nb1 1
        xct mhs
        dac nh2
        dac nh2 1
        jmp ml0
```

```
/ control word get routines

mg1,    dap mg3
        cli
        iot 11
mg3,    jmp .

mg2,    dap mg4
        lat
        swap
mg4,    jmp .

ml1,    lac .               / 1st control word
        sza i               / zero if not active
        jmp mq1             / not active
        swap
        idx moc
        spi
        jmp mq4
        law 1
        add ml1
        dap ml2
        law 1
        add mx1
        dap mx2
        law 1
        add my1
        dap my2
        law 1
        add ma1
        dap ma2
        law 1
        add mb1
        dap mb2
mot,    lac .
        dap sp5
ml2,    lac .               / 2nd control word
        spq             / can it collide?
        jmp mq2             / no
mx1,    lac .               / calc if collision
mx2,    sub .               / delta x
        spa                 / take abs val
        cma
        dac mt1
        sub me1             / < EPSILON ?
        sma
        jmp mq2             / no
my1,    lac .
my2,    sub .
        spa
        cma
        sub me1             / < epsilon ?
        sma
        jmp mq2             / no
        add mt1
        sub me2
        sma
```

```
        jmp mq2
        lac (mex 400000     / yes, EXPLODE
        dac i ml1     / replace calc routine with explosion
        dac i ml2
        lac i mb1     / duration of explosion
mb2,    add .
        cma
        sar 8s
        add (1
ma1,    dac .
ma2,    dac .
mq2,    idx mx2             / end of comparison loop
        idx my2
        idx ma2
        idx mb2
        index ml2, (lac mtb nob, ml2
```

```
mq4,    lac i ml1     / routine for calculating spaceship
        dap . 1               / or other object and displaying it
        jsp .
mb1,    lac .                 / alter count of number of instructions
        add mtc
        dac mtc
mq1,    idx mx1               / end of comparison and display loop
        idx my1
        idx ma1
        idx mb1
        idx mdx
        idx mdy
        idx mom
        idx mth
        idx mas
        idx mfu
        idx mtr
        idx mot
        idx mco
        idx mh1
        idx mh2
        idx mh3
        idx mh4
        index ml1, (lac mtb nob-1, ml1
        lac i ml1     / display and compute last point
        sza i                 / if active
        jmp mq3
        dap . 1
        jsp .
        lac i mb1
        add mtc
        dac mtc
mq3,    background    / display stars of the heavens
        jsp blp               / display massive star
        count mtc, .          / use up rest of time of main loop
        jmp ml0               / repeat whole works
```

```
/ misc calculation routines

        / explosion

mex,    dap mxr
        lac i mdx
        sar 3s
        add i mx1
        dac i mx1
        lac i mdy
        sar 3s
        add i my1
        dac i my1
        law mst
        dap msh
        lac i mb1       / time involved
        cma cli-opr
        sar 3s
        dac mxc
ms1,    sub (140
        sma
        idx msh
mz1,    random
        and (777
        ior (scl
        dac mi1
        random
        scr 9s
        sir 9s
msh,    xct .
mi1,    hlt
        add i my1
        swap
        add i mx1
        dpy-i 300
        count mxc, mz1
        count i ma1, mxr
        dzm i ml1
mxr,    jmp .

mst,    scr 1s
        scr 3s

/ torpedo calc routine

tcr,    dap trc
        count i ma1, tc1
        lac (mex 400000
        dac i ml1
        law i 2
        dac i ma1
        jmp trc

tc1,    lac i mx1
        sar 9s
        xct the
        add i mdy
        dac i mdy
```

```
        sar 3s
        add i my1
        dac i my1
        sar 9s
        xct the
        add i mdx
        dac i mdx
        sar 3s
        add i mx1
        dac i mx1
        dispt i, i my1, 1
trc,    jmp .
```

```
/ hyperspace routines

/ this routine handles a non-colliding ship invisibly
/ in hyperspace

hp1,    dap hp2
        count i ma1, hp2
        law hp3             / next step
        dac i ml1
        law 7
        dac i mb1
        random
        scr 9s
        sir 9s
        xct hr1
        add i mx1
        dac i mx1
        swap
        add i my1
        dac i my1
        random
        scr 9s
        sir 9s
        xct hr2
        dac i mdy
        dio i mdx
        setup hpt,3
        lac ran
        dac i mth
hp4,    lac i mth
        sma
        sub (311040
        spa
        add (311040
        dac i mth
        count hpt,hp4
        xct hd2
        dac i ma1
hp2,    jmp .

/ this routine handles a ship breaking out of
/ hyperspace.

hp3,    dap hp5
        count i ma1,hp6
        lac i mh1
        dac i ml1
        law 2000
        dac i mb1
        count i mh2,hp7
        dzm i mh2
```

```
hp7,    xct hd3
        dac i mh3
        lac i mh4
        add hur
        dac i mh4
        random
        ior (400000
        add i mh4
        spa
        jmp hp5
        lac (mex 400000
        dac i ml1
        law i 10
        dac i ma1
        law 2000
        dac i mb1
hp6,    lac i mx1
        dispt i, i my1, 2
hp5,    jmp .
```

```
/ spaceship calc

ss1,    dap srt             / first spaceship
        jsp i cwg
        dio scw
        jmp sr0

ss2,    dap srt             / second spaceship
        jsp i cwg
        rir 4s
        dio scw

sr0,

sc1,    lio scw             /control word
        clf 6 cla-opr       /update angle
        spi
        add maa
        ril 1s
        spi
        sub maa
mom,    add .
        dac i mom
        szs 10
        jmp sr8
        dzm i mom
        ral 7s
sr8,    ril 1s
        spi
        stf 6
        lio i mfu
        spi i
        clf 6

mth,    add .
        sma
        sub (311040
        spa
        add (311040
        dac i mth
        jda sin
        dac sn
        dzm bx
        dzm by
        szs 60
        jmp bsg
        lac i mx1
        dac t1
        mul t1
        scr 1s
        dac acx
        cla
        scr 2s
        dio iox
        lac i my1
        dac t1
        mul t1
        scr 1s
        dac acy
```

```
        cla
        scr 2s
        swap
        add iox
        swap
        scl 2s
        add acx
        add acy
        sub str
        sma i sza-skp
        jmp pof
        add str
        varsft
        dac t1
        jda sqt
        mul t1
        undosft
        scr 9s
        scr 6s
        szs i 20            / switch 2 for light star
        scr 2s
        sza
        jmp bsg
        scr 1s
        dio t1
        integrate mx1, bx
        integrate my1, by
bsg,    cla
        sad i mfu
        clf 6
        lac i mth
        jda cos
        dac cs
        sar 9s
        xct sac
        szf i 6
        cla
        add by
        diff mdy, my1, (sar 3s
        lac sn
        sar 9s
        xct sac
        cma
        szf i 6
        cla
        add bx
        diff mdx, mx1, (sar 3s
sp1,    scale sn, 5s, ssn
sp2,    scale cs, 5s, scn
        lac i mx1
```

```
        sub ssn
        dac sx1
        sub ssn
        dac stx
        lac i my1
        add scn
        dac sy1
        add scn
        dac sty
        scale sn, 9s, ssn
        scale cs, 9s, scn
        lac ssn
        dac ssm
        add scn
        dac ssc
        dac ssd
        lac ssn
        sub scn
        dac csn
        cma
        dac csm
        lac scn
        dac scm
        cla cli-opr
        dpy-4000
sp5,    jmp .
sq6,    ioh
        ranct sar 9s, sar 4s, src
        lio scw
        ril 2s
        spi i                   / not blasting
        jmp sq9                 / no tail
sq7,    scale sn, 8s, ssn
        scale cs, 8s, scn
        count i mfu, st2
        dzm i mfu
        jmp sq9

st2,    yincr sx1, sy1, sub
        dispt i, sy1
        count src,sq7
sq9,    count i ma1, sr5    / check if torp tube reloaded
        dzm i ma1     / prevent count around
mco,    lac .                   / previous contro word
        cma
        szs i 30
        clc
        and scw         / present control word
        ral 3s                  / torpedo bit to bit 0
        sma
        jmp sr5                 / no launch
        count i mtr, st1    / check if torpedos exhausted
        dzm i mtr               / prevent count around
        jmp sr5
st1,    init sr1, mtb           / search for unused object
sr1,    lac .
        sza i                   / 0 if unused
        jmp sr2
        index sr1, (lac mtb nob, sr1
        hlt                     / no space for new objects
        jmp .-1
```

```
sr2,    lac (tcr            / set up torpedo calc
        dac i sr1
        law nob
        add sr1
        dap ss3
        lio stx
ss3,    dio .
        add (nob
        dap ss4
        lio sty
ss4,    dio .
        add (nob
        dap sr6
        add (nob
        dap sr7
        add (nob
        dap sr3
        add (nob
        dap sr4
        lac sn
        xct tvl
        cma
        add i mdx
sr3,    dac .
        lac cs
        xct tvl
        add i mdy
sr4,    dac .
        xct rlt
        dac i ma1       / permit torp tubes to cool
trf,    xct tlf         / life of torpedo
sr6,    dac .
        law 20
sr7,    dap .                   / length of torp calc.
sr5,    count i mh3, st3        / hyperbutton active?
        dzm i mh3
        lac i mh2
        sza i
        jmp st3
        lac scw
        cma
        ior i mco
        and (600000
        sza
        jmp st3
        lac i ml1
        dac i mh1
        lac (hp1 400000
        dac i ml1
        xct hd1
        dac i ma1
        law 3
        dac i mb1
st3,
st,     jmp .
```

→ LAC I MCO
CMA
DAC I MCO
→ JMP .

```
/ here to handle spaceships dragged into star


/ spaceship in star

pof,    dzm i mdx
        dzm i mdy
        szs 50
        jmp po1
        lac (377777
        dac i mx1
        dac i my1
        lac i mb1
        dac ssn
        count ssn, .
        jmp srt

po1,    lac (mex 400000     / now go bang
        dac i ml1
        law i 10
        dac i ma1
        jmp srt
```

```
/ outlines of spaceships

ot1,    111131
        111111
        111111
        111163
        311111
        146111
        111114
        700000
. 5/

ot2,    013113
        113111
        116313
        131111
        161151
        111633
        365114
        700000
. 5/


        constants
        variables
p,      . 200/          / space for patches

mtb,                    / table of objects and their properties

start 4
```

```
spacewar game saver patch

mg1=1510
ran=31

/+ tw → punch
/- tw → read

40/
cwr,    dap cwx
        lat

cw2,    cks
        ril 1s
        spi+spa i-skp
        jmp cw1
        rrb
        rpa-i
cw3,    rir 4s
cwx,    jmp .

cw1,    ril 3s
        spi+sma i-skp
        jmp cw2
        jsp mg1
        ril 4s
        ppa-i
        jmp cw3

6000/                           /new starting address
go,     lat
        sma
        jmp pu
        rpb
        dio ran
        rpa-i
        jmp 4

pu,     law i 200
        dac pc
        cli
        ppa
        isp pc
        jmp .-2
        lio ran
        ppb             ril 6s
        ppb             ril 6s
        ppb-i
        jmp 4

variables

        start go
```

1j	6077
1q	6117
1sc	3151
2j	6121
2q	6141
2sc	3152
3j	6143
3q	6403
4j	6405
4q	7747
a	1402
a1	1374
a2	1437
a3	1470
a4	1420
a40	1377
a5	1414
a6	1431
acx	3162
acy	3164
bcc	1257
bck	746
bcx	752
bds	534
bjm	533
bkc	1260
blp	466
blx	513
bpt	514
bpx	735
bsg	2317
bx	3135
by	3136
cos	100
cs	3165
csm	3127
csn	3132
csx	146
cwg	3153
cwr	40
ddd	20
fgr	32
fid	22
fie	15
fin	6
flo	55
flp	45
foo	12
fou	14
fpo	54
fpr	1261
frr	13
fs	3
fuu	34

fx	35
fyn	17
gct	3154
grv	32
hd1	23
hd2	24
hd3	25
hp1	2001
hp2	2061
hp3	2062
hp4	2051
hp5	2123
hp6	2120
hp7	2074
hr1	26
hr2	27
hur	30
iox	3163
ma1	1610
ma2	1611
maa	13
mb1	1624
mb2	1604
mco	2466
md1	1346
mdn	1352
mdx	3140
mdy	3141
me1	16
me2	17
mex	1667
mfu	3142
mg1	1510
mg2	1514
mg3	1513
mg4	1520
mh1	3144
mh2	3145
mh3	3146
mh4	3147
mhs	22
mi1	1731
ml1	1521
ml2	1552
ml0	1262
moc	3155
mom	2143
mot	1550
mq1	1627
mq2	1612
mq3	1662
mq4	1621
ms1	1706
msh	1730

mst	1745
mt1	3156
mtb	3371
mtc	3137
mth	2157
mtr	3143
mx1	1555
mx2	1556
mxc	3157
mxr	1744
my1	1565
my2	1566
mz1	1711
na1	3501
nb1	3531
nco	3653
ndx	3561
ndy	3611
nfu	3645
nh1	3655
nh2	3657
nh3	3661
nh4	3663
nnn	3665
nob	30
nom	3641
not	3651
ntd	3150
nth	3643
ntr	3647
nx1	3421
ny1	3451
oc	230
oc1	375
oc2	420
oc3	426
oc4	434
oc5	442
oc6	450
oc9	460
occ	3123
ocd	411
oce	402
ocg	252
och	253
oci	3124
ocj	250
ock	241
ocm	373
ocn	374
oco	264
ocp	266
ocq	265
ocr	267

ocs	22[illegible]
ocx	372
ocz	227
ot1	2626
ot2	2643
p	3171
po1	2621
pof	2605
ran	31
rlt	10
sac	14
sbf	61
sc1	2134
scm	3125
scn	3114
scw	3160
sft	66
si1	112
si2	147
si3	117
sin	106
sn	3161
sp1	2353
sp2	2356
sp5	2417
sq1	220
sq2	221
sq3	171
sq6	2420
sq7	2437
sq9	2463
sqt	162
sqx	174
sr1	2504
sr2	2514
sr3	2543
sr4	2547
sr5	2556
sr6	2553
sr7	2555
sr8	2151
src	3170
sr0	2134
srt	2604
ss1	2124
ss2	2130
ss3	2522
ss4	2526
ssa	3133
ssc	3131
ssd	3130
ssi	3134
ssm	3126
ssn	3113

st1	2502
st2	2451
st3	2602
str	15
stx	3166
sty	3167
sx1	3121
sy1	3122
t1	3116
t2	3117
tc1	1757
tcr	1747
the	21
tlf	11
tno	6
trc	2000
trf	2552
tv1	7
v2	3
xys	3115
xyt	3120