AD-A034 039 HUMAN RESOURCES RESEARCH ORGANIZATION ALEXANDRIA VA F/G 9/2
ANSWER BOOKLET TO BASIC COMPUTER PROGRAMMING: A SELF-INSTRUCTIO--ETC(U)
JUN 67 R J SEIDEL, H G HUNTER, I C ROTBERG DA-44-188-ARO-2

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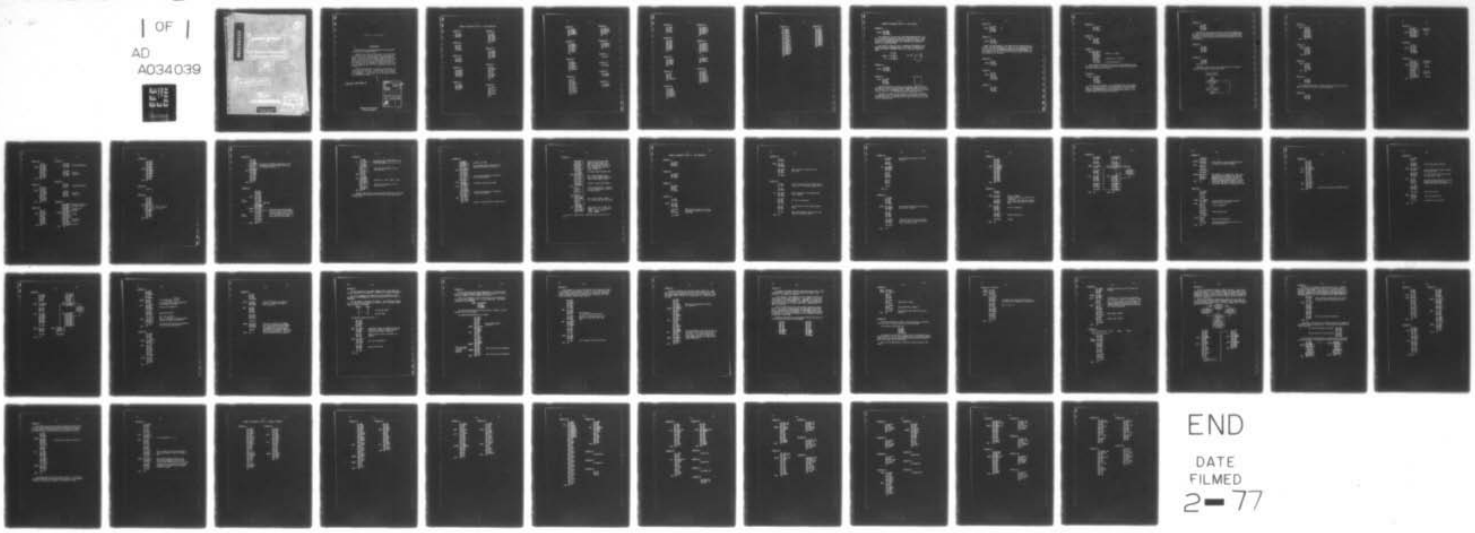

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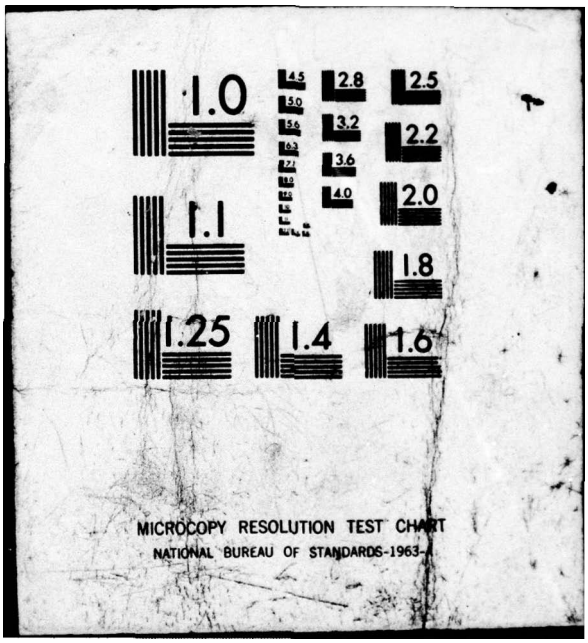
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

ANSWER BOOKLET

to

Basic Computer Programming: A Self-Instructional Course

ANSWER BOOKLET

Instructions

The answers for the problems given in the test booklet are coded in the following manner:

There are four phases in the course -- I, II, III, and IV. You will notice that the pages of the text booklet are marked at the top of each page with the appropriate phase number. Within the individual phases, there are parts, such as Part One, Part Two, etc. As the problems are given in the text material, they are numbered according to the part in which they appear. For example, on a page marked III at the top, a problem numbered 3.2 would be Problem 2 of Part Three of Phase III.

In this Answer Booklet, the answers to the problems are coded exactly the same way. The phase number will be at the top of each page. The answers will be listed, for example, as: Problem 3.2. (meaning that this is the answer to Problem 2 of Part Three of Phase _ _ _).

DA 44-188-ARO-2

I

ANSWERS TO PROBLEMS OF PHASE I: BASIC OPERATIONS

Problem 3.1.

```
CLA EENY
ADD MEENY
ADD MINY
```

Problem 3.2.

```
CLA LEAVE
ADD AWOL
ADD TDY
STR ABSENT
```

Problem 3.3.

```
CLA VALUE
ADD VALUE
STR VALUE
```

Problem 3.4.

```
CLA REGPAY
ADD OVTPAY
SUB SOCSEC
SUB INCTAX
STR NETPAY
```

Problem 3.5.

```
CLA PENCIL
SUB ERASER
SUB ERASER
STR PEN
```

Problem 3.6.

```
CLA RCVD
ADD STOCK
SUB ISSUE1
SUB ISSUE2
SUB ISSUE3
STR STOCK
HLT
```

Problem 3.7.

```
CLA REGPAY
ADD OVTPAY
STR TOTPAY
SUB DEDUCT
STR NETPAY
HLT
```

Problem 3.8.

```
CLA EW
ADD EWCOME
SUB EWGO
STR EW
CLA EM
ADD EMCOME
SUB EMGO
STR EM
HLT
```

Problem 3.9.

```
CLA RECORD
STR X
ADD RECORD
STR Y
ADD RECORD
STR Z
HLT
```

Problem 4.1.

```
CLA RECORD
ADD RECORD+1
SUB RECORD+2
STR RECORD+3
HLT
```

Problem 4.2.

```
CLA WORKER
STR WORKER+1
CLA SALARY
STR SALARY+1
CLA TAXES
STR TAXES+1
HLT
```

Problem 4.3.

```
CLA MAN
STR WORKER
CLA MAN+1
STR WORKER+1
CLA MAN+2
STR WORKER+2
HLT
```

Problem 4.4.

```
CLA STOCK
ADD GET
SUB ISSUE
STR STOCK+1
ADD GET+1
SUB ISSUE+1
STR STOCK+2
ADD GET+2
SUB ISSUE+2
STR STOCK+3
HLT
```

Problem 4.5.

```
CLA EMPLOY+1
ADD EMPLOY+4
ADD EMPLOY+7
STR LOYAL
HLT
```

Problem 4.6.

```
CLA EMPLOY+1
SUB EMPLOY+1
STR EMPLOY+1
HLT
```

Problem 5.1.

```
CLA PAYRT
```

Problem 5.2.

```
STR GROPAY
```

Problem 5.3.

```
CLA BADGNO
STR OUTPUT
```

Problem 5.4.

```
CLA RETIRE
STR OVTRET
```

Problem 5.5.

```
CLA SPACE
STR LOC1
STR LOC2
STR LOC3
```

Problem 5.6.

```
CLA SPACE
ADD VERB
ADD VERB
ADD QUANT
ADD QUANT
ADD QUANT
STR MOS1
HLT
```

Problem 5.7.

```
CLA REGPAY
ADD OVTPAY
SUB DEDUCT
STR NETPAY
HLT
```

Problem 5.8.

```
CLA PAY
ADD PAY
STR PAY
STR RECORD+18
HLT
```

Problem 5.9.

```
CLA EMPLOY
STR OUTPUT
CLA EMPLOY+5
STR OUTPUT+1
CLA EMPLOY+6
STR OUTPUT+2
HLT
```

Problem 5.10.

```
CLA EMPLOY+1
ADD EMPLOY+2
ADD EMPLOY+3
ADD EMPLOY+4
STR DEDUCT
HLT
```

Problem 5.11.

```
CLA EMPLOY+5
SUB EMPLOY+1
SUB EMPLOY+2
SUB EMPLOY+3
SUB EMPLOY+4
STR EMPLOY+6
HLT
```

-or-

```
CLA EMPLOY+5
SUB DEDUCT
STR EMPLOY+6
HLT
```

Problem 5.12.

```
CLA REGTIM
ADD OVRTIM
ADD BONUS
SUB EMPLOY+1
SUB EMPLOY+2
SUB EMPLOY+3
SUB EMPLOY+4
STR EMPLOY+5
HLT
```

Problem 5.13.

```
CLA EMPLOY
STR EMNUM
CLA REGTIM
STR TOTPAY
CLA OVRTIM
STR TOTPAY+1
CLA BONUS
STR TOTPAY+2
CLA EMPLOY+1
STR DEDUCT
CLA EMPLOY+2
STR DEDUCT+1
CLA EMPLOY+3
STR DEDUCT+2
CLA EMPLOY+4
STR DEDUCT+3
CLA EMPLOY+5
STR NETPAY
HLT
```

Problem 5.14.

```
CLA AMMO
SUB HEUSED
STR AMMO
CLA AMMO+1
SUB APUSED
STR AMMO+1
CLA AMMO+2
SUB CMUSED
STR AMMO+2
CLA AMMO+3
SUB PRUSED
STR AMMO+3
HLT
```

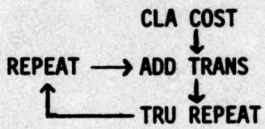
ANSWERS TO PROBLEMS OF PHASE II: BASIC LOOPING

Problem 1.1.

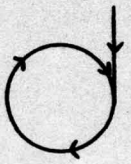
```
        CLA COST
REPEAT  ADD TRANS
        TRU REPEAT
```

The problem asks for the sum of COST+TRANS+TRANS+TRANS+etc. We can get one COST by writing CLA COST; but to add more than one TRANS it is necessary to transfer back to the ADD TRANS instruction again and again. TRU REPEAT does just that, transferring the computer to REPEAT, which names ADD TRANS.

As a result, a loop or circle is formed from TRU REPEAT back to ADD TRANS, giving the endless series: ADD TRANS, TRU REPEAT, ADD TRANS, TRU REPEAT, ADD TRANS, and so on. The loop is diagramed below:



the loop:

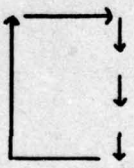


Problem 1.2.

```
        CLA PANTS
REPEAT  ADD SUITS
        TRU REPEAT
```

Problem 1.3.

```
AGAIN   CLA COUNT
        SUB ONE
        STR COUNT
        TRU AGAIN
```



There are two points to notice in this program. The first is the STR COUNT instruction, which erases the contents of COUNT and copies in the contents of the accumulator. Thus, if COUNT starts with a 5, SUB ONE brings it down to 4, and STR COUNT erases the 5 and copies in a 4.

Secondly, the symbolic location AGAIN is placed beside CLA COUNT so the instructions will be repeated starting with CLA COUNT. Notice that if COUNT started with a 5 before the first loop, it will have a 4 at the start of the second loop.

Problem 1.4.

```
        CLA LOOPS
AGAIN   SUB ONE          OR
        STR LOOPS
        TRU AGAIN
```

Problem 1.5.

```
        CLA ZRO
REPEAT  ADD COST
        TRU REPEAT
```

Notice what would happen if the accumulator were not zeroed with CLA ZRO. The ADD command adds the number from the location addressed (in this case, COST) to whatever is already in the accumulator. If the accumulator started with some number from a previous program and we did not clear it out with CLA ZRO, the program would add that previous number to all the COSTs.

Problem 1.6.

```
        CLA ZRO
AGAIN   ADD HAT
        TRU AGAIN
```

Problem 1.7.

```
        CLA ZRO
LOOPER  ADD HAT
        ADD COAT
        ADD GLOVE
        TRU LOOPER
```

Problem 2.1.

```
        CLA COUNT
        SUB ONE
        STR COUNT
```

Problem 2.2.

```
        CLA LOOPER
        SUB ONE
        STR LOOPER
```

Problem 2.3.

```
LOWER   CLA CASE
        SUB ONE
        STR CASE
        TRU LOWER
```

Problem 2.4.

```
AGAIN   CLA CARD      adding a 1 to CARD
        ADD ONE
        STR CARD

        CLA FILE      subtracting a 1 from FILE
        SUB ONE
        STR FILE

        TRU AGAIN     the loop instruction
```

This program can be thought of in terms of three component blocks: one block to add a 1 to CARD, a second block to subtract a 1 from FILE, and a final instruction for looping.

Problem 2.5.

```
REPEAT  CLA COUNT
        SUB ONE
        SUB ONE
        STR COUNT
        TRU REPEAT
```

The clue to this problem is in understanding how the SUB command works. It changes the number in the accumulator, leaving the changed number in the accumulator for the next instruction. Or think of it this way: You have repeated the ADD command several times in a row; the SUB command can be treated the same way.

Problem 3.1.

```
        CLA COUNT
        SUB ONE
        STR COUNT
        TRZ STOP
```

Incidentally, the program would work in exactly the same way if TRZ STOP were written as the third instruction, with STR COUNT fourth. The reason is that neither TRZ nor STR disturbs the contents of the accumulator. We will keep placing TRZ STOP fourth simply as a matter of convenience.

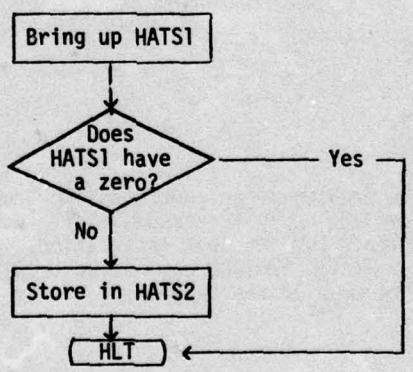
Problem 3.2.

```
        CLA LOOPS
        SUB ONE
        STR LOOPS
        TRZ STOP
```

Problem 3.3.

```
        CLA HATS1
        TRZ STOP
        STR HATS2
STOP    HLT
```

Programmers often work out their programs using "flow charts." Problem 3.3 is shown as a flow chart below:



Problem 3.4.

```
REPEAT  CLA FILE
        ADD ONE
        STR FILE
        CLA CARD
        SUB ONE
        STR CARD
        TRZ STOP
        TRU REPEAT
STOP    HLT
```

Problem 3.5.

```
DOWN    CLA MANY
        SUB ONE
        STR MANY
        TRZ STOP
        TRU DOWN
STOP    HLT
```

Problem 3.6.

```
LOWER   CLA DECK
        SUB UNIT
        STR DECK
        TRZ STOP
        TRU LOWER
STOP    HLT
```

Problem 4.1.

```
        CLA ONCE
        ADD MANY
        STR MANY
```

The program adds the basic number (in ONCE) to the answer location (MANY), storing the sum back in the answer location.

Problem 4.2.

```
        CLA LACE
        ADD SHOE
        STR SHOE
```

Problem 4.3.

```
        CLA ZRO          Cleaning out
        STR TOTAL          garbage
REPEAT  CLA PAYOFF
        ADD TOTAL        Adding
        STR TOTAL
        TRU REPEAT
```

Problem 4.4.

```
        CLA ZRO
        STR VALUE
REPEAT  CLA SUIT
        ADD VALUE
        STR VALUE
        TRU REPEAT
```

Problem 4.5.

```
        CLA ZRO          Cleaning out
        STR TOTAL          garbage
REPEAT  CLA SALARY
        ADD TOTAL        Adding
        STR TOTAL

        CLA MEN
        SUB ONE          Test for
        STR MEN            completion
        TRZ STOP

        TRU REPEAT       Looping
STOP    HLT
```

Problem 4.6.

```
        CLA ZRO
        STR GROSS
AGAIN   CLA PRICE
        ADD GROSS
        STR GROSS
        CLA SALES
        SUB ONE
        STR SALES
        TRZ STOP
        TRU AGAIN
STOP    HLT
```

Problem 4.7.

```
        CLA ZRO
        STR VALUE
REPEAT  CLA PRICE
        ADD VALUE
        STR VALUE
        CLA PENCIL
        SUB K1
        STR PENCIL
        TRZ STOP
        TRU REPEAT
STOP    HLT
```

Problem 4.8.

```
        CLA ZRO
        STR ALL
MULT    CLA THREE
        ADD ALL
        STR ALL
        CLA MEN
        SUB UNIT
        STR MEN
        TRZ STOP
        TRU MULT
STOP    HLT
```

Problem 5.1.

```
        CLA SOLD2
        TRZ STOP      Program preparation
        STR COUNT

        CLA COUNT
        SUB ONE       Test for
        STR COUNT     completion
        TRZ STOP
```

Problem 5.2.

```
        CLA AGE
        TRZ STOP      Program preparation
        STR OLD

        CLA OLD
        SUB ONE       Test for
        STR OLD       completion
        TRZ STOP
```

Problem 5.3.

```
        CLA COUNT     Checking and saving
        TRZ STOP      the loop counter
        STR TEMP
        CLA ZRO       Cleaning out
        STR VALUE     garbage
REPEAT  CLA COST
        ADD VALUE     Adding
        STR VALUE

        CLA TEMP
        SUB ONE       Test for
        STR TEMP      completion
        TRZ STOP

        TRU REPEAT    Looping
STOP    HLT
```

Problem 5.4.

```
          CLA HAND+1
          TRZ STOP
          STR HAND+2
          CLA ZRO
          STR HAND+3
WASH      CLA HAND
          ADD HAND+3
          STR HAND+3
          CLA HAND+2
          SUB KON1
          STR HAND+2
          TRZ STOP
          TRU WASH
STOP      HLT
```

Problem 6.1.

Program C

Problem 6.2.

```
          CLA SOLD
          TRZ STOP
          STR TEMP
          CLA ZRO
          STR TOTAL
SELL      CLA BIG
          ADD LITTLE
          ADD TOTAL
          STR TOTAL
          CLA TEMP
          SUB ONE
          STR TEMP
          TRZ STOP
          TRU SELL
STOP      HLT
```

This is the only tricky part.

Problem 6.3.

```
        CLA SOLD
        TRZ STOP
        STR COUNT
        CLA HORNS
        STR BLOW
        CLA ZRO
        STR HORNS
POST    CLA PRICE
        ADD HORNS
        STR HORNS
        CLA COUNT
        SUB ONE
        STR COUNT
        TRZ STOP
        TRU POST
STOP    HLT
```

You should save HORNS by relocating it into BLOW before zeroing out HORNS, used later as the answer location.

Problem 6.4.

```
                CLA ASK
                STR COUNT
                CLA ZRO
                STR TOTAL
        FIRST   CLA TUBE
                ADD TOTAL
1st             STR TOTAL
Program         CLA COUNT
                SUB CON     (Not ONE)
                STR COUNT
                TRZ SECOND
                TRU FIRST
- - - - - - - - - - - - - - - - - -
        SECOND  CLA ASK+1
                STR COUNT+1
        THIRD   CLA TUBE+1
                ADD TOTAL
2nd             STR TOTAL
Program         CLA COUNT+1
                SUB CON
                STR COUNT+1
                TRZ STOP
                TRU THIRD
- - - - - - - - - - - - - - - - - -
        STOP    HLT
```

Since you cleaned out garbage from the answer location TOTAL during program preparation for the first program, you needn't do it again for the second.

Problem 6.5.

```
        CLA MEN
        STR TEMP
IN      CLA MEAL1
        ADD AVAIL
        STR AVAIL
        CLA TEMP
        SUB K
        STR TEMP
        TRZ NEXT
        TRU IN
NEXT    CLA VIP
        TRZ STOP
        STR VISIT
OUT     CLA AVAIL
        SUB MEAL2
        STR AVAIL
        CLA VISIT
        SUB K
        STR VISIT
        TRZ STOP
        TRU OUT
STOP    HLT
```

Do not zero out location AVAIL; you need that number.

1st test for completion; it uses TEMP, not MEN.

Subtraction: AVAIL - MEAL2 = AVAIL

2nd test for completion; it uses VISIT, not VIP.

Program preparation for the second program could have been accomplished along with preparation for the first, eliminating symbolic location NEXT.

Problem 6.6.

```
        CLA NUM1
        TRZ NEXT
        STR COUNT1
        CLA ZRO
        STR TOTAL1
        STR TOTAL2
TYPE1   CLA PRICE1
        ADD TOTAL1
        STR TOTAL1
        CLA COUNT1
        SUB DIGIT
        STR COUNT1
        TRZ NEXT
        TRU TYPE1
NEXT    CLA NUM2
        TRZ BOTH
        STR COUNT2
TYPE2   CLA PRICE2
        ADD TOTAL2
        STR TOTAL2
        CLA COUNT2
        SUB DIGIT
        STR COUNT2
        TRZ BOTH
        TRU TYPE2
BOTH    CLA TOTAL1
        ADD TOTAL2
        STR BIGTOT
        HLT
```

Use NEXT, not STOP.

Zero out both answer locations at the beginning; it saves an instruction.

1st test for completion, transferring to the second program.

If there's nothing, go to BOTH.

2nd test for completion, transferring to final instruction.

Symbolic location STOP isn't needed at all.

Problem 6.7.

```
        CLA COST
        TRZ NEXT
        CLA ITEMS
        TRZ NEXT
        TRZ NEXT
        STR ITEMS
        CLA ZRO
        STR FIRST
        STR SECOND
LOOP1   CLA COST
        ADD FIRST
        STR FIRST
        CLA ITEMS
        SUB KON
        STR ITEMS
        TRZ NEXT
        TRU LOOP1
NEXT
        CLA A
        TRZ LAST
        CLA B
        TRZ LAST

LOOP2   CLA A
        ADD SECOND
        STR SECOND
        CLA B
        SUB KON
        STR B
        TRZ LAST
        TRU LOOP2
LAST    CLA FIRST
        SUB SECOND
        STR ANSWER
        HLT
```

You don't need to save either number so leave them in the same locations, transferring to the second program if either is zero. Remember CLA does not change storage loc.

Zero both answer locations here.

This routine computes FIRST = COST x ITEMS by adding COST into FIRST as many times as ITEMS.

Transfer to the second program.

These instructions say, "Transfer to final computations if either A or B equals zero."

This routine computes SECOND = A x B, using B as the loop counter.

Since FIRST = COST x ITEMS, and SECOND = A x B, it follows that (COST x ITEMS) - (A x B) = (FIRST - SECOND).

That was a tough problem. Congratulations if you got it all right.

ANSWERS TO PROBLEMS OF PHASE III: DATA PROCESSING

Problem 1.1.

```
        CLA REPEAT
        ADD ONE
        STR REPEAT
```

Problem 1.2.

```
        CLA HUBERT
        ADD DIGIT
        STR HUBERT
```

Problem 1.3.

```
        CLA LOWER
        ADD ONE
        ADD ONE
        STR LOWER
```

Problem 1.4.

```
        CLA ZRO
        STR FINAL

REPEAT  CLA VALUE
        ADD FINAL
        STR FINAL

        CLA REPEAT      Change VALUE to VALUE+1 so that on
        ADD K           the next loop VALUE+1 will be added
        STR REPEAT      into FINAL.

        TRU  REPEAT
```

Problem 1.5.

```
          CLA ZRO
          STR EVERY

AGAIN     CLA COST
          ADD EVERY
          STR EVERY

          CLA AGAIN        COST is modified to COST+2 for the
          ADD TWO          next loop.
          STR AGAIN

          TRU AGAIN
```

Problem 1.6.

```
          CLA MEN          (There is no need for a TRZ STOP instruc-
          STR TEMP         tion since 16 is obviously greater than 0.)

          CLA ZRO
          STR TOTAL

SELL      CLA SALES        Add in the number of sales made by the
          ADD TOTAL        first salesman.
          STR TOTAL

          CLA TEMP
          SUB ONE          The test for completion.
          STR TEMP
          TRZ STOP

          CLA SELL         Get the address for the second salesman
          ADD ONE          ready.
          STR SELL

          TRU SELL         Start the loop again  to add in the sales
                           made by the second salesman.
STOP      HLT
```

Problem 1.7.

```
          CLA TYPES        (You have been told there is at least
          STR POP          one type.)

          CLA ZRO
          STR SALES

    HIT   CLA RECORD
          ADD SALES
          STR SALES

          CLA POP
          SUB K1
          STR POP
          TRZ STOP

          CLA HIT
          ADD K1
          STR HIT

          TRU HIT

   STOP   HLT
```

Problem 1.8.

```
          CLA ITEMS
          TRZ STOP
          STR HOLD
          CLA ZRO
          STR HOURS

 REPEAT   CLA TUBE+3       The 4th word has the hours the tube was
          ADD HOURS        used, which is TUBE+3.
          STR HOURS

          CLA HOLD
          SUB ONE
          STR HOLD
          TRZ STOP

          CLA REPEAT       Since each record is four words long,
          ADD FOUR         we add a 4 to get to the corresponding
          STR REPEAT       word in the next record.

          TRU REPEAT

   STOP   HLT
```

Problem 1.9.

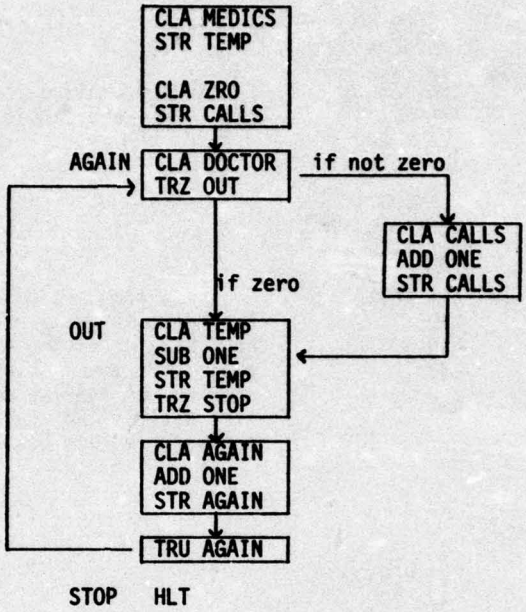
```
          CLA HELP
          TRZ STOP
          STR TEMP
          CLA ZRO
          STR REGPAY
TOTAL     CLA RECORD+2
          ADD REGPAY
          STR REGPAY
          CLA TEMP
          SUB CON1
          STR TEMP
          TRZ STOP
          CLA TOTAL
          ADD CON4
          STR TOTAL
          TRU TOTAL
STOP      HLT
```

Problem 2.1.

```
          CLA ZRO
          STR BONUS

CHECK     CLA PUSH        Copy in a number.
          TRZ TEST        If it's a zero, skip to the test for
                          completion.
          CLA BONUS       If it's not zero, count the salesman
          ADD UNIT        here; he must have made at least one
          STR BONUS       sale.

TEST      CLA MEN
          SUB UNIT        Test for completion.
          STR MEN
          TRZ STOP

          CLA CHECK
          ADD UNIT        Address modification.
          STR CHECK

          TRU CHECK       Looping.

STOP      HLT
```

Problem 2.2.

```
        CLA MEDICS
        STR TEMP

        CLA ZRO
        STR CALLS

AGAIN   CLA DOCTOR
        TRZ OUT

        CLA CALLS
        ADD ONE
        STR CALLS

OUT     CLA TEMP
        SUB ONE
        STR TEMP
        TRZ STOP

        CLA AGAIN
        ADD ONE
        STR AGAIN

        TRU AGAIN

STOP    HLT
```



Problem 2.3.

```
          program
          preparation
REPEAT    CLA TAXES
          TRZ GETHIM      If the number is zero, the man has not paid
                          his taxes, and should be counted.
TEST      test for
          completion
          address
          modification
          TRU REPEAT
GETHIM    CLA NOTYET
          ADD K1          Non-taxpayers are counted here.  When these
          STR NOTYET      instructions are performed, they come im-
          TRU TEST        mediately after the transfer instruction;
                          since this means skipping the test for com-
                          pletion and address modification, a transfer
                          instruction (TRU TEST) is needed to go back
                          and perform them before starting another loop.
STOP      HLT
```

Problem 2.4.

```
          CLA PERSON
          TRZ STOP
          STR FILE
          CLA ZRO
          STR EM
REPEAT    CLA NUMBER+2
          TRZ ENLIST      A zero indicates an enlisted personnel;
                          transfer out to count him.
FINAL     CLA FILE
          SUB K1          Test for completion.
          STR FILE
          TRZ STOP
          CLA REPEAT
          ADD K4          Address modification.
          STR REPEAT
          TRU REPEAT
ENLIST    CLA EM
          ADD K1          Count enlisted personnel.
          STR EM
          TRU FINAL       You have transferred out of the loop, so
                          you must get back in.
STOP      HLT
```

Problem 2.5.

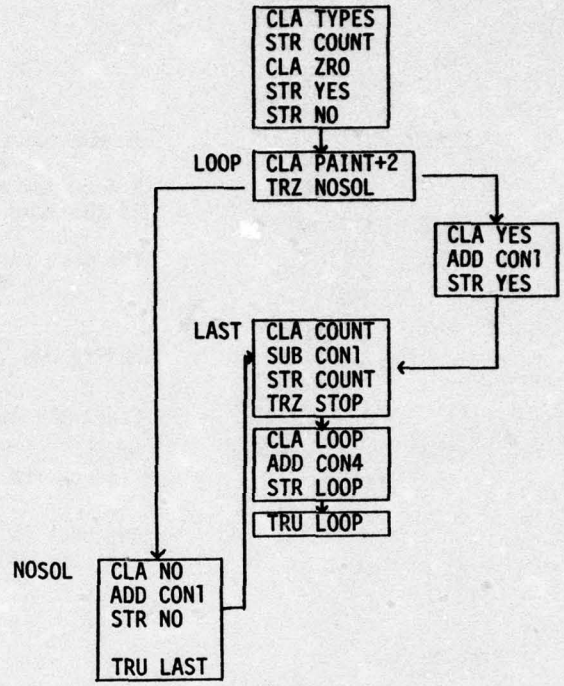
```
        CLA FIRM
        TRZ STOP
        STR SAVE
        CLA ZRO
        STR SINGLE
CYCLE   CLA WORKER+3
        TRZ FREE
DONE    CLA SAVE
        SUB ONE
        STR SAVE
        TRZ STOP
        CLA CYCLE
        ADD SIX
        STR CYCLE
        TRU CYCLE
FREE    CLA SINGLE
        ADD ONE
        STR SINGLE
        TRU DONE        Continue the loop where you transferred out.
STOP    HLT
```

Problem 2.6.

```
         CLA PLANES
         STR FLY

         CLA ZRO
         STR ONTIME        Zero out both answer locations.
         STR LATE

CHECK    CLA FLIGHT+4
         TRZ GOOF          Zeroes indicate late flights; transfer
                           out to count them.
         CLA ONTIME
         ADD ONE           If a flight wasn't late (a 0), it was
         STR ONTIME        on time; count it here.

TEST     CLA FLY
         SUB ONE           All loops must end with a test for com-
         STR FLY           pletion and address modification,
         TRZ STOP          whether they involve a transfer or not.

         CLA CHECK
         ADD FIVE
         STR CHECK

         TRU CHECK         Start the next loop.

GOOF     CLA LATE
         ADD ONE           Count late flights here.
         STR LATE

         TRU TEST          Go back and finish the loop.

STOP     HLT
```

Problem 2.7.

```
        CLA TYPES
        STR COUNT
        CLA ZRO
        STR YES
        STR NO

LOOP    CLA PAINT+2
        TRZ NOSOL

        CLA YES
        ADD CON1
        STR YES

LAST    CLA COUNT
        SUB CON1
        STR COUNT
        TRZ STOP
        CLA LOOP
        ADD CON4
        STR LOOP

        TRU LOOP

NOSOL   CLA NO
        ADD CON1
        STR NO

        TRU LAST

STOP    HLT
```



Problem 3.1.

```
          CLA TOTAL
          TRZ STOP
          STR NUMBER

          CLA ZRO
          STR MEDIUM
REPEAT    CLA BRA          If the number was:  A B C D
          SUB TWO                              1 2 3 4 ,
          TRZ COUNT              it is now:   -1 0 1 2 .
                           A zero now marks a B-bra; transfer out
                           of the loop to count them.
LAST      CLA NUMBER
          SUB ONE          The test for completion.
          STR NUMBER
          TRZ STOP

          CLA REPEAT
          ADD ONE          Modify BRA to BRA+1.
          STR REPEAT

          TRU REPEAT       Start the loop again.
COUNT     CLA MEDIUM       Add a 1 to MEDIUM for the B-bra identi-
          ADD ONE          fied by the sorting instructions.
          STR MEDIUM

          TRU LAST         Get back in the loop for the completion
                           test and address modification.
STOP      HLT
```

Problem 3.2.

```
          CLA TOTAL
          STR TEMP
          CLA ZRO
          STR LOYAL
CHECK     CLA WORKER+2
          SUB K20
          TRZ TWENTY
OVER      CLA TEMP
          SUB ONE
          STR TEMP
          TRZ STOP
          CLA CHECK
          ADD K5
          STR CHECK
          TRU CHECK
TWENTY    CLA LOYAL
          ADD ONE
          STR LOYAL
          TRU OVER
STOP      HLT
```

Problem 3.3.

```
         CLA LIST
         STR MEN
         CLA ZRO
         STR PASSES

CYCLE    CLA EM+3          To pick out the 0's, 1's, and 2's,
         SUB THREE         subtract 3 to make them negative
         TRN DETAIL        (-3, -2, and -1).

END      CLA MEN
         SUB ONE
         STR MEN
         TRZ STOP

         CLA CYCLE
         ADD FIVE
         STR CYCLE

         TRU CYCLE

DETAIL   CLA PASSES        Notice that counting occurs before
         ADD ONE           the test for completion, even though
         STR PASSES        the instructions are written after;
                           the computer skips directly down on
         TRU END           TRN DETAIL when a negative number ap-
                           pears in the accumulator.  This is why
STOP     HLT               you must TRU back up after counting.
```

Problem 3.4.

You are interested in all numbers greater than 2, which means you are not interested in the numbers 0, 1, and 2--or the numbers less than 3.

So, if you subtract 3, the numbers you are not interested in will be negative in the accumulator, and you can TRN directly to the test for completion.

Take the numbers 0 through 4, for example. You do not want to count 0's, 1's, and 2's, but you do want to count 3's and 4's. See what happens when you subtract 3 from each.

Before	After	
0	-3	
1	-2	do not count these
2	-1	
3	0	
4	1	do count these

The complete program, therefore, is:

```
        CLA FIGHT
        TRZ STOP
        STR FIGURE
        CLA ZRO
        STR LOST
MORE    CLA TRAIN+2     Subtracting 3 makes the numbers you are not
        SUB CON3        interested in negative, and you can TRN
        TRN DONE        directly to the test for completion.
        CLA LOST
        ADD CON1        Numbers that are left are the ones to be
        STR LOST        counted.
DONE    CLA FIGURE
        SUB CON1
        STR FIGURE      The test for completion.
        TRZ STOP
        CLA MORE
        ADD CON4        Address modification.
        STR MORE
        TRU MORE
STOP    HLT
```

Problem 3.5.

First, look just at the sorting instructions. You want to count the 1's starting at symbolic location MONTH1 (for January) and the 2's starting at symbolic location MONTH2 (for February).

Thus, if you subtract 2, the 2's will be 0's in the accumulator and the 1's will be negative, or -1, in the accumulator. The sorting instructions are, therefore:

```
COMPUT  CLA VACUUM+4
        SUB TWO
        TRN MONTH1
        TRZ MONTH2
```

The TRN and TRZ instructions can be reversed, of course. The program will still work the same.

The complete program would be as follows:

```
                CLA TUBES
                TRZ STOP
                STR HOLD
                CLA ZRO
                STR JAN          Zero out both answer
                STR FEB          locations.
COMPUT          CLA VACUUM+4
                SUB TWO
                TRN MONTH1
                TRZ MONTH2
LAST            CLA HOLD
                SUB ONE
                STR HOLD
                TRZ STOP
                CLA COMPUT
                ADD SIX
                STR COMPUT
                TRU COMPUT
MONTH1          CLA JAN
                ADD ONE
These two blocks STR JAN
of instructions TRU LAST         Back to the test for completion.
could be        CLA FEB
switched.       ADD ONE
                STR FEB
                TRU LAST         Back to the test for completion.
STOP            HLT
```

Problem 3.6.

Of the numbers 2, 4, and 6, the ones you want to count are 2 and 6. If you subtract 4, they become -2, 0, and +2. This allows you to TRN to count small-sized shirts, TRZ directly to the test for completion (these are medium-sized shirts and you're not interested), and count large-sized shirts directly after sorting.

```
        CLA TOTAL
        TRZ STOP
        STR NUMBER
        CLA ZRO
        STR SMALL
        STR LARGE
SORT    CLA SHIRT
        SUB KON4
        TRN COUNT       2's are now -2
        TRZ END         0's indicate medium-sized shirts
        CLA LARGE       Whatever is left started out as a 6
        ADD KON1        and is still positive; count them
        STR LARGE       here.
END     CLA NUMBER
        SUB KON1
        STR NUMBER
        TRZ STOP
        CLA SORT
        ADD KON1
        STR SORT
        TRU SORT
COUNT   CLA SMALL
        ADD KON1
        STR SMALL
        TRU END         Don't forget to finish out the loop.
STOP    HLT
```

Problem 3.7.

You want to subtract 8 to make the "middle" number zero. Then you can TRZ to count marginal men, TRN to count the men who flunked, and count the men accepted after the rest have been eliminated. Since the largest number available for subtraction is a 4, simply subtract it twice.

```
        CLA PUPIL
        STR MEN
        CLA ZRO
        STR FLUNK       Now you have three answer locations.
        STR MARGIN      Zero them all.
        STR ACCEPT
LOOPER  CLA OFFCAN+T
        SUB FOUR
        SUB FOUR
        TRN OUT
        TRZ MAYBE
        CLA ACCEPT
        ADD ONE
        STR ACCEPT
LAST    CLA MEN
        SUB ONE
        STR MEN
        TRZ STOP
        CLA LOOPER
        ADD FOUR
        STR LOOPER
        TRU LOOPER      This marks the end of the loop in terms of
OUT     CLA FLUNK       the actual order in which instructions are
        ADD ONE         carried out.  The counting instructions
        STR FLUNK       are written at the end, but they are per-
        TRU LAST        formed before the test for completion and
MAYBE   CLA MARGIN      address modification.
        ADD ONE
        STR MARGIN
        TRU LAST
STOP    HLT
```

Problem 3.8.

The numbers 0 through 6 represent tubes that are all right. Tubes represented by 7 through 12 are to be checked, and numbers 13 and greater are for tubes to be replaced.

If you subtract 7, the numbers 0-6 will be negative and you can TRN directly to the test for completion. The numbers 7-12, the tubes to be checked, will become numbers 0-5. Therefore, if you then subtract again, using a 6, the tubes to be checked will be represented by negative numbers and you can TRN to count them. Anything left is a tube to be replaced.

There is another way to solve this problem, perhaps the one you chose. If you start by subtracting 6, the tubes that are all right will be represented by either negative or zero numbers, and you can TRN and TRZ to the test for completion. If you then subtract another 6, the tubes to be checked have negative or zero numbers, and you can TRN and TRZ to count them.

Assuming you got the rest of the program correct, the sorting instructions will be either of the following:

```
CLA TUBE
SUB SIX
SUB ONE
TRN TEST
SUB SIX
TRN LOOK
CLA REMOVE
ADD ONE
STR REMOVE
```

```
CLA TUBE
SUB SIX
TRN TEST
TRZ TEST
SUB SIX
TRN LOOK
TRZ LOOK
CLA REMOVE
ADD ONE
STR REMOVE
```

Problem 4.1.

```
FIRST   CLA COST
SECOND  STR COST+100
        CLA K100
        SUB K1
        STR K100
        TRZ STOP
        CLA FIRST
        ADD K1          Change COST to COST+1.
        STR FIRST
        CLA SECOND
        ADD K1          Change COST+100 to COST+101.
        STR SECOND
        TRU FIRST       On the second loop, COST+1 will go into
                        COST+101.
STOP    HLT
```

Problem 4.2.

This isn't as tough as it looks. If you gave up on it, read the clues below and try it again before looking at the answer.

The relocation instructions are:

```
CLA COST
STR VALUE
CLA ZRO
STR VALUE+1
```

On the next loop, you want to relocate COST+1 into VALUE+2 and put zero into VALUE+3. So all three addresses must be changed during address modification. Ask yourself what addresses you need in place of COST, VALUE, and VALUE+1 for the second loop.

Now try the problem again and then turn to the next page for the answer.

Problem 4.2. (continued)

```
FIRST   CLA COST
SECOND  STR VALUE
        CLA ZRO
THIRD   STR VALUE+1

        CLA CON100
        SUB CON1
        STR CON100      The address (the name) of the location is
        TRZ STOP        the same, but its contents are now different.

        CLA FIRST
        ADD CON1        Add a 1, not a 2.
        STR FIRST

        CLA SECOND
        ADD CON2
        STR SECOND

        CLA THIRD
        ADD CON2
        STR THIRD

        TRU FIRST

STOP    HLT
```

Problem 4.3

```
          CLA VOLUMS      (Notice the spelling; only six letters are
          STR CHECK       allowed.)
          CLA ZRO
          STR OUT

READER    CLA BOOK
          TRZ DONE
MARK      STR FINE        If BOOK has a 1, it is still in the accumu-
          CLA OUT         lator and can be stored, or relocated, in FINE.
          ADD K1          The 1 cannot be added to OUT with another STR
          STR OUT         command, however, since STR first erases the
DONE      CLA CHECK       location addressed, before copying in the num-
          SUB K1          ber from the accumulator.
          STR CHECK
          TRZ STOP

          CLA READER
          ADD K1          Modify BOOK to BOOK+1.
          STR READER

          CLA MARK
          ADD K1          Modify FINE to FINE+1.
          STR MARK

          TRU READER

STOP      HLT
```

Problem 4.4.

Here's what you want: TUBE TUBE+1 TUBE+2

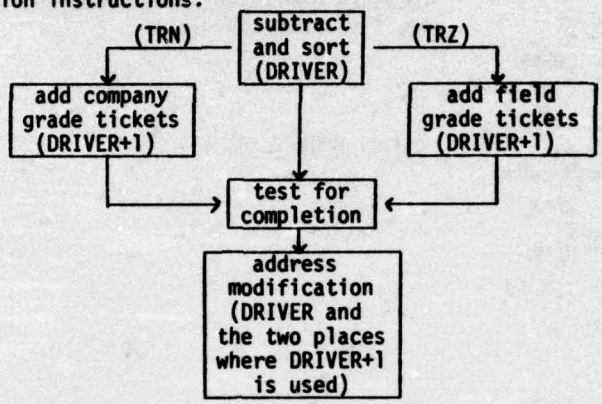
And here's how to do it:

```
          CLA TOTAL
          STR COUNT

FIRST     CLA TUBE+2
SECOND    STR TUBE+1

          CLA COUNT
          SUB ONE
          STR COUNT
          TRZ STOP

          CLA FIRST
          ADD TWO
          STR FIRST

          CLA SECOND
          ADD ONE
          STR SECOND

          TRU FIRST

STOP      HLT
```

Problem 4.5.

Look at this problem in terms of a block flow chart. The sorting instructions subtract 2 (the "middle" number), making the numbers in the accumulator negative, zero, or positive. Negative numbers then indicate company grade officers, zeroes are field grade, and positive numbers are for general officers, which can then be eliminated by going directly to the test for completion.

Notice in the complete program below that two words are used, but one of them appears twice (in the two counting blocks) which means that it must be modified in both places, resulting in three blocks of address modification instructions.




```
        CLA TOTAL
        STR HOLD
        CLA ZRO
        STR FINE
        STR WARN
TICKET  CLA DRIVER
        SUB K2
        TRN BAR
        TRZ LEAF
OVER    CLA HOLD
        SUB K1
        STR HOLD
        TRZ STOP
        CLA TICKET
        ADD K3
        STR TICKET
        CLA BAR
        ADD K3
        STR BAR
          (continued in next
           column)
```

```
        CLA LEAF
        ADD K3
        STR LEAF
        TRU TICKET
BAR     CLA DRIVER+1
        ADD FINE
        STR FINE
        TRU OVER
LEAF    CLA DRIVER+1
        ADD WARN
        STR WARN
        TRU OVER
STOP    HLT
```

Problem 5.1.

You have only one symbolic location (besides STOP). Therefore, you can't start the loop with CLA ZRO since you need the symbolic location to modify TRASH. The solution is to CLA ZRO as the last instruction in program preparation and also as the last instruction in the loop. Remember that transfer commands do not change numbers in the accumulator, so it is still there for the STR TRASH instruction.

```
        CLA ITEM
        STR SAVE      (81 is obviously greater than zero; there is
        CLA ZRO        no need to insert a TRZ STOP instruction.)
NEXT    STR TRASH
        CLA SAVE
        SUB KON
        STR SAVE
        TRZ STOP
        CLA NEXT
        ADD KON
        STR NEXT
        CLA ZRO       This is the critical instruction.
        TRU NEXT
STOP    HLT
```

Incidentally, you may have noticed that just about any problem can be solved in several different ways. Take the adding instructions you learned long ago.

To add COST repeatedly into TOTAL:

```
CLA COST
ADD TOTAL
STR TOTAL
```

But you could just as easily write:

```
CLA TOTAL
ADD COST
STR TOTAL
```

The instructions need not occur as a single block of consecutive instructions either. You add COST into TOTAL in the following ways:

```
        CLA ZRO
        STR TOTAL
REPEAT  ADD TOTAL
        STR TOTAL
          test for
        completion
          address
        modification
        CLA COST
        TRU REPEAT
STOP    HLT
```

-- or --

```
        CLA ZRO
REPEAT  STR TOTAL
          test for
        completion
          address
        modification
        CLA TOTAL
        ADD COST
        TRU REPEAT
STOP    HLT
```

Problem 5.2.

```
        CLA NUM
        SUB ONE
        STR HOLD
FIRST   CLA MAN
        ADD ONE
TOTAL   STR TEMP
        CLA HOLD
        SUB ONE
        STR HOLD
        TRZ STOP
        CLA FIRST
        ADD ONE
        STR FIRST
        CLA TOTAL
        ADD ONE
        STR TOTAL
        TRU FIRST
STOP    HLT
```

Problem 5.3.

```
        CLA ZRO
        STR ANSWER
ITEM    CLA SORT
        TRZ LAST
        TRN LAST
        CLA ANSWER
        ADD KON
        STR ANSWER
LAST    CLA TOTAL
        SUB KON
        STR TOTAL
        TRZ STOP
        CLA ITEM
        ADD KON
        STR ITEM
        TRU ITEM
STOP    HLT
```

Problem 5.4.

```
        CLA ITEMS
        TRZ STOP
        STR TEMP
        CLA ZRO
        STR NEED
        STR EXCESS
COMPUT  CLA SUPPLY+2
        SUB KON2
        TRN ORDER
        TRZ DONE
        CLA EXCESS
        ADD KON1
        STR EXCESS
DONE    CLA TEMP
        SUB KON1
        STR TEMP
        TRZ STOP
        CLA COMPUT
        ADD KON6
        STR COMPUT
        TRU COMPUT
ORDER   CLA NEED
        ADD KON1
        STR NEED
        TRU DONE
STOP    HLT
```

Problem 5.5.

This problem asks you to count the 20's (persons who will be 21 next year) and the numbers greater than 20 (persons 21 or older now). So if you subtract 20, negative numbers can be eliminated, zeroes are persons 20 years old, and what's left are persons 21 and older.

```
          CLA ZRO
          STR NOW
          STR LATER

COMPUT    CLA DATA
          SUB CONST          To subtract 20, subtract 21 and add 1.
          ADD CON1
          TRN TEST
          TRZ NEXTYR

          CLA NOW
          ADD CON1
          STR NOW

TEST      CLA TOWN
          SUB CON1
          STR TOWN
          TRZ STOP

          CLA COMPUT
          ADD CON1
          STR COMPUT

          TRU COMPUT

NEXTYR    CLA LATER
          ADD CON1
          STR LATER

          TRU TEST

STOP      HLT
```

This problem could be solved a variety of ways. This is one of the shorter solutions, but yours may work just as well. The important criterion is not how long a program is, but whether it works.

Problem 5.6.

```
          CLA OFFCAN
          TRZ STOP
          STR MEN

          CLA ZRO
          STR PLUS
          STR VALUE

DATA      CLA APPLY+4
          SUB KON2
          TRN ACCEPT        1 (for acceptance) - 2 = -1

LAST      CLA MEN
          SUB KON1
          STR MEN
          TRZ STOP

          CLA DATA
          ADD KON5
          STR DATA

          CLA ACCEPT        Get the address for the next candidate's
          ADD KON5          test score, whether or not it is actually
          STR ACCEPT        used.

          TRU DATA

ACCEPT    CLA APPLY+3       When these instructions are used, they
          ADD VALUE         are performed before the test for com-
          STR VALUE         pletion, even though they are written after.

          CLA PLUS          (If test scores are added before accepted
          ADD KON1          candidates are counted, only one symbolic
          STR PLUS          location is needed.)

          TRU LAST

STOP      HLT
```

ANSWERS TO PROBLEMS OF PHASE IV: ADVANCED TECHNIQUES

Problem 1.1.

```
        CLA STOCK1
        STR TEMP
        CLA STOCK2
        STR TEMP+1
        CLA ZRO
        STR VALSTK
        STR VALSTK+1
        STR TOTAL
        CLA VALSTK
        ADD VALUE
        STR VALSTK
        CLA TEMP
        SUB KON
        STR TEMP
        TRZ *+2
        TRU *-7
        CLA VALSTK+1
        ADD VALUE+1
        STR VALSTK+1
        CLA TEMP+1
        SUB KON
        STR TEMP+1
        TRZ *+2
        TRU *-7
        CLA VALSTK
        ADD VALSTK+1
        STR TOTAL
        HLT
```

Problem 1.2.

```
        CLA STOCK
        STR TEMP
        CLA ZRO
        STR TOTAL
NEXT    CLA TUBE
        TRZ COMPUT
        CLA VALUE
        ADD TOTAL
        STR TOTAL
LAST    CLA TEMP
        SUB KON
        STR TEMP
        TRZ *+9
        CLA NEXT
        ADD KON
        STR NEXT
        TRU NEXT
COMPUT  CLA VALUE+1
        ADD TOTAL
        STR TOTAL
        TRU LAST
        HLT
```

Problem 1.3.

```
        CLA NUM
        TRZ STOP
        STR COUNT
        CLA ZRO
        STR HDQTS
        STR MS
        STR NOTREQ
        CLA INFO+5
        SUB K2
        TRN HDQTOT
        TRZ MASEC
        CLA NOTREQ
        ADD K1
        STR NOTREQ
LAST    CLA COUNT
        SUB K1
        STR COUNT
        TRZ STOP
        CLA LAST-7
        ADD K6
        STR LAST-7
        TRU LAST-7
HDQTOT  CLA HDQTS
        ADD K1
        STR HDQTS
        TRU LAST
MASEC   CLA MS
        ADD K1
        STR MS
        TRU LAST
STOP    HLT
```

Problem 1.4.

```
        CLA MEN
        TRZ STOP
        CLA ZRO
        STR TOTEM
DATA    CLA INFO
        TRN EM
        CLA MEN
        SUB K1
        STR MEN
        TRZ STOP
        CLA DATA
        ADD K3
        STR DATA
        TRU DATA
EM      CLA TOTEM
        ADD K1
        STR TOTEM
        TRU DATA+2
STOP    HLT
```

Problem 1.5.

```
        CLA PERSON
        STR HOLD
        CLA ZRO
        STR UP
RANK    CLA RATING
        SUB KON
        TRZ SECOND
LAST    CLA HOLD
        SUB KON
        STR HOLD
        TRZ STOP
        CLA RANK
        ADD K5
        STR RANK
        TRU RANK
SECOND  CLA RATING+2
        SUB TIME
        ADD KON
        TRN LAST
        CLA UP
        ADD KON
        STR UP
        TRU LAST
STOP    HLT
```

Problem 1.6.

```
        CLA COUNT
        TRZ STOP
        CLA ZRO
        STR TOT
NEXTOT  CLA STAT
        TRN AGAIN
        CLA COUNT
        SUB K1
        STR COUNT
        TRZ STOP
        CLA NEXTOT
        ADD K1
        STR NEXTOT
        TRU NEXTOT
AGAIN   CLA TOT
        ADD K1
        STR TOT
        CLA AGAIN
        ADD K1
        STR AGAIN
        TRU NEXTOT+2
STOP    HLT
```

Problem 1.7a

```
        CLA COMPY
        STR HOLD
OLD     CLA RECORD
        STR UPDATE
        CLA RECORD+1
        STR UPDATE+1
        CLA RECORD+2
        STR UPDATE+2
        CLA UPDATE+1
        SUB UPDATE+2
        STR UPDATE+3
        CLA HOLD
        SUB K1
        STR HOLD
        TRZ STOP
        CLA OLD
        ADD K3
        STR OLD
        CLA OLD+1
        ADD K4
        STR OLD+1
        CLA OLD+2
        ADD K3
        STR OLD+2
        CLA OLD+3
        ADD K4
        STR OLD+3
        CLA OLD+4
        ADD K3
        STR OLD+4
        CLA OLD+5
        ADD K4
        STR OLD+5
        CLA OLD+6
        ADD K4
        STR OLD+6
        CLA OLD+7
        ADD K4
        STR OLD+7
        CLA OLD+8
        ADD K4
        STR OLD+8
        TRU OLD
STOP    HLT
```

Problem 1.7b

```
        CLA COMPY
        STR NUM
        CLA ZRO
        STR TOTAL
SUM     CLA UPDATE+3
        ADD TOTAL
        STR TOTAL
        CLA NUM
        SUB K1
        STR NUM
        TRZ STOP
        CLA SUM
        ADD K4
        STR SUM
        TRU SUM
STOP    HLT
```

Problem 2.1.

```
        SUB COST,IR3
```

Problem 2.2.

```
        STR BOOK,IR1
```

Problem 2.3.

```
        CLA IR1
        ADD ONE
        STR IR1
```

Problem 2.4.

```
        CLA MEN
        STR TEMP
        CLA ZRO
        STR IR2
SELL    ADD SALES,IR2
        STR TOTAL
        CLA TEMP
        SUB ONE
        STR TEMP
        TRZ STOP
        CLA IR2
        ADD ONE
        STR IR2
        CLA TOTAL
        TRU SELL
STOP    HLT
```

Problem 2.5.

```
        CLA TYPES
        STR POP
        CLA ZRO
        STR IR1
HIT     ADD RECORD,IR1
        STR SALES
        CLA POP
        SUB K1
        STR POP
        TRZ STOP
        CLA IR1
        ADD K1
        STR IR1
        CLA SALES
        TRU HIT
STOP    HLT
```

Problem 2.6.

```
        CLA HELP
        STR IR4
        CLA ZRO
        STR IR3
TOTAL   ADD RECORD+2,IR3
        STR REGPAY
        CLA IR4
        SUB CON1
        STR IR4
        TRZ STOP
        CLA IR3
        ADD CON4
        STR IR3
        CLA REGPAY
        TRU TOTAL
STOP    HLT
```

Problem 3.1.

```
        LOD ZRO,,IR1
```

Problem 3.2.

```
        LOD MAN,,IR2
```

Problem 3.3.

```
        LOD COUNT,,IR3
```

Problem 3.4.

```
        LOD ZRO,,IR2
        LOD TOTAL,,IR1
        CLA ZRO
```

Problem 3.5.

```
          LOD ZRO,,IR3
          LOD TEN,,IR1
          CLA ZRO
CRAVAT    ADD TIE,IR3
          STR ANSWER
          CLA IR1
          SUB ONE
          STR IR1
          TRZ STOP
          CLA IR3
          ADD ONE
          STR IR3
          CLA ANSWER
          TRU CRAVAT
STOP      HLT
```

Problem 3.6.

```
          LOD ITEMS,,IR1
          LOD ZRO,,IR2
          CLA ZRO
REPEAT    ADD TUBE+3,IR2
          STR HOURS
          CLA IR1
          TRZ STOP
          SUB ONE
          STR IR1
          TRZ STOP
          CLA IR2
          ADD FOUR
          STR IR2
          CLA HOURS
          TRU REPEAT
STOP      HLT
```

Problem 4.1.

```
          LOD MEN,,IR2
          LOD ZRO,,IR1
          CLA ZRO
          ADD PUSH,IR1
          TRX *-1,IR1,1
          STR BONUS
          HLT
```

Problem 4.2.

```
          LOD MEDICS,,IR3
          LOD ZRO,,IR2
          CLA ZRO
          ADD DOCTOR,IR2
          TRX *-1,IR2,1
          STR CALLS
          HLT
```

Problem 4.3.

```
          LOD ARRIVE,,IR2
          LOD ZRO,,IR1
          LOD LEAVE,,IR4
          LOD ZRO,,IR3
          CLA ZRO
          ADD IN,IR1
          TRX *-1,IR1,1
          ADD OUT,IR3
          TRX *-1,IR3,1
          STR TOTAL
          HLT
```

Problem 5.1.

```
        LDX 6,IR1,0
        CLA ZRO
        ADD TYPE,IR1
        TRX *-1,IR1,1
        STR TOTAL
        HLT
```

Problem 5.2.

```
        LDX 4,IR2,0
        CLA ZRO
        ADD PAY,IR2
        TRX *-1,IR2,1
        STR GROSS
        HLT
```

Problem 5.3.

```
        LDX 3,IR2,0
        CLA PAY
        ADD PAY+1,IR2
        TRX *-1,IR2,1
        STR GROSS
        HLT
```

Problem 6.1.

```
START   CLA STOCK
        STR TEMP
        CLA ZRO
        STR VALSTK
        CLA VALSTK
        ADD VALUE
        STR VALSTK
DONE    CLA TEMP
        SUB ONE
        STR TEMP
        TRZ DONE+8
        CLA DONE-2
        ADD ONE
        STR DONE-2
        TRU DONE-3
        HLT
```

Problem 6.2.

```
        CLA STOCK
        STR TEMP
        CLA ZRO
        STR VALSTK
COMPUT  CLA VALSTK
        ADD VALUE
        STR VALSTK
        CLA TEMP
        SUB ONE
        STR TEMP
        TRZ *+5
        CLA *-6
        ADD ONE
        STR *-8
        TRU COMPUT
        HLT
```

Problem 6.3.

```
        ADD PAY,IR3
```

Problem 6.4.

```
        STR COST,IR2
```

Problem 6.5.

```
        LOD VALUE,,IR4
```

Problem 6.6.

```
          LOD ZRO,,IR1
          LOD TOTUBE,,IR2
          CLA ZRO
REPEAT    ADD TUBE+1,IR1
          STR VALUE
          CLA IR2
          TRZ STOP
          SUB KON1
          STR IR2
          TRZ STOP
          CLA IR1
          ADD KON3
          STR IR1
          CLA VALUE
          TRU REPEAT
STOP      HLT
```

Problem 6.7.

```
          LOD ZRO,IR1
          LOD DAY,IR2
          CLA ZRO
AGAIN     ADD INFO+3,IR1
          STR TOTAL
          CLA IR2
          TRZ STOP
          SUB ONE
          STR IR2
          TRZ STOP
          CLA IR1
          ADD FOUR
          STR IR1
          CLA TOTAL
          TRU AGAIN
STOP      HLT
```

Problem 6.8.

```
          LOD ZRO,,IR2
          LOD TUNE,,IR3
          CLA ZRO
          ADD TYPE,IR2
          TRX *-1,IR2,1
          STR ANSWER
          HLT
```

Problem 6.9.

```
          LOD ZRO,,IR3
          LOD RENT,,IR4
          CLA ZRO
          ADD INCOME,IR3
          TRX *-1,IR3,1
          STR ALL
          HLT
```

Problem 6.10.

```
          LDZ 70,IR4,0
          CLA ZRO
          ADD PAY,IR4
          TRX*-1,IR4,1
          STR TOTSAL
          HLT
```

Problem 6.11.

```
          LDX 20,IR1,0
          CLA ZRO
          ADD PRICE,IR1
          TRX *-1,IR1,1
          STR ALL
          HLT
```

Problem 6.12.

```
        LOD ZRO,,IR1
        LOD STOCK,,IR2
        CLA ZRO
        STR TOT
        CLA TUBE,IR1
        SUB KON
        TRN *+6
        CLA VALUE
        ADD TOT
        STR TOT
        TRX *-6,IR1,1
        HLT
        CLA VALUE+1
        ADD TOT
        STR TOT
        TRU *-5
```

Problem 6.13.

```
        LOD PERSON,,IR4
        LOD ZRO,,IR3
        CLA ZRO
        STR UP
        CLA RATING,IR3
        SUB KON
        TRZ *+6
        ADD KON
        TRX *-4,IR3,1
        HLT
        STR UP
        TRU *-6
        CLA RATING+2
        SUB TIME
        TRN *-9
        TRZ *-10
        TRU *-8
```

Problem 6.14.

```
        LDX 90,IR2,0
        CLA ZRO
        STR INV
        CLA UNI,,IR2
        TRZ *+6
        ADD INV
        ADD VALUE
        STR INV
        TRX *-5,IR2,1
        HLT
        CLA VALUE+1
        ADD INV
        STR INV
        TRU *-5
```

Problem 6.15.

```
        LDX 6,IR1,0
        CLA ZRO
        ADD TYPE,IR1
        TRX *-1,IR1,1
        STR TOTAL
        LOD TOTAL,IR4
        LOD ZRO,IR3
        CLA ZRO
        ADD COST,IR3
        TRX *-1,IR3,1
        STR VALUE
        HLT
```