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MEMORANDUM

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To: PEP Users

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Subject: PROPCO Routines in PEP

Contents



## I. Introduction

Recently, it has been clear that many different types of corrections can be applied to the computed observables in PEP. These include corrections that are internally calculated (such as from the MEDIA and ATMION subroutines) and corrections that are externally derived (such as DRVID or the various types of S-X plasma corrections).

The PROPCO subroutine package was designed to allow flexibility in the calculation, use and availability of the many corrections. All available corrections are kept in a vector, the CAL vector, that can be written and read from an obslib tape. Thus corrections external to PEP can be written on an OBSLIB tape and read into PEP, and corrections calculated in PEP can be written out onto the tape for future use. PROPCO also makes it possible to apply the best set of corrections for every observation, instead of a fixed set for the entire run.

## II. Obslib Tape Vectors

Three new vectors and a scalar have been added to the OBSLIB tape. They are:

| | |
|---|---|
| NCAL | The length of the vectors to be placed on the tape |
| CAL(I) | Stores the actual correction |
| SCAL(I) | Stores an error estimate of the actual correction |
| ICAL(I) | Stores the rank of the correction; used in deciding which correction to use |

The types of corrections and their positional assignments within the new vectors are as follows:

| I | CORRECTION NAME | RANK | OBS. TYPE | |
|---|---|---|---|---|
| 1 | STATIC NEUTRAL ATMOSPHERE | 2 | TMDLY | CALCULATED IN ATMION |
| 2 | STATIC NEUTRAL ATMOSPHERE | 2 | DOP | |
| 3 | ACTIVE TERRESTRIAL | 2 | TMDLY | |
| 4 | NEUTRAL ATMOSPHERE | 2 | DOP | |
| 5 | PASSIVE TERRESTRIAL | 3 | TMDLY | |
| 6 | IONOSPHERE | 3 | DOP | |
| 7 | ACTIVE TERRESTRIAL | 3 | TMDLY | |
| 8 | IONOSPHERE | 3 | DOP | |
| 9 | SOLAR PLASMA | 1 | TMDLY | |
| 10 | CALCULATED IN MEDIA | 1 | DOP | |
| 11 | STATIC SX FROM RNGNS | 20 | TMDLY | |
| 12 | CALIBRATIONS FROM DOPNS | 20 | DOP | |
| 13 | EXTRAPOLATED (in time) | 17 | TMDLY | |
| 14 | PLASMA CORRECTIONS (SX) | 17 | DOP | |
| 15 | RANGE CAL. VIA INTEGRATED S-X DOPPLER | 18 | TMDLY | |
| 16 | Not used | | | |
| 17 | RANCAL RANGE CALIBRATIONS | 5 | TMDLY | |

This list can be expanded as new corrections are implemented. In the above list, the term "active" and "passive" have the following meaning:

> Active corrections are derived from actual physical measurement of the effect (as in S/X corrections) or from physical measurements of the conditions behind the effect (as in the active atmosphere part of ATMION, which uses temperature and humidity as inputs). Passive measurements, on the other hand, are calculated by a table lookup or from long term average values, as in subroutine MEDIA.

The rank of the above corrections, stored in ICAL, has been arbitrarily assigned and, for the present, cannot be changed using input controls. The meanings of the ranks are:

| | |
|---|---|
| 0 | No correction available |
| 1 | Passive correction - calculated from table lookup or other standard, nonresponsive model |
| 2 | Neutral media (atmosphere) corrections generally << solar plasma correction and compatible with most active corrections |
| 3 | Dispersive planetary media (ionosphere) corrections also generally << solar plasma correction, but not compatible with most active corrections |
| 5 | RANCAL corrections supplied by JPL. These are due to delays introduced in the spacecraft and ground equipment. |
| 17 | Plasma corrections derived from extrapolation in time of S-X or S-3/11X data. Calculated in SXCAL subroutines RNGXS, DOPXS. Uplink plasma assumed = downlink plasma. |
| 18 | Correction calculated in SXCAL subroutine RNGIDS. Derived from integrated Doppler polynomials and range points. Uplink = downlink plasma. |
| 20 | Correction calculated in SXCAL subroutines RNGNS and DOPNS. No time extrapolation was necessary. Uplink = downlink plasr |

## III. How to Use PROPCO

PROPCO has only been implemented in the RAD routines of PEP. Therefore it is necessary to have ICT(43) = 1. A new vector, JCAL, has been added to NMLST1. In addition, one new scalar, KCAL, and several JCT's must be set. All of these will be described below.

Note that corrections to be applied to time delay measurements are in odd positions and corrections to be applied to Doppler measurements are in even positions. For the rest of this memo, this convention will be referred to as the "parity" of a correction.

The JCAL vector in the input stream corresponds to the CAL vectors that are on the OBSLIB tapes, and the positional assignments are the same as listed in Section II. The ones digit and the tens digit of each JCAL(I) have independent meanings. The 1's place refers to the calculation of a correctio and the 10's place refers to its use:

| | | |
|---|---|---|
| 1's place | 1: | Unconditionally do not calculate this correction |
| | 2: | Calculate only if indicated by "normal" logic |
| | 3: | Unconditionally calculate this correction |
| 10's place | 1: | Unconditionally do not use this correction |
| | 2: | Use this correction only if indicated by "normal" logic |
| | 3: | Unconditionally use this correction. |

The "normal" logic that is referred to is as follows. There is normal logic for the use of a correction and normal logic for the calculation of a correction:

USE: Use only the highest ranked corrections.
Use every compatible class of correction.

CALCULATION:
If the correction exists on tape, do not re-calculate it
If the correction does not exist on tape, calculate it if it is going to be used.

Use of the JCAL = "3x" override option.
When the tens digit of any correction is a 3, then the standard logic is overridden for all corrections with the same parity. In this case, only the corrections with a 3 in their JCAL tens digit will be used. No search for rank and no compatibility tests will be performed. In this manner, the override option can be used for either TMDLY or DOP (or both) without affecting the other correction type.

Use of the JCT(2) default.
JCT(2) is the default value for all those JCAL's not set by the user in the PEP input stream.
JCT(2) has the same format as the JCAL vector, that is, it is a two-digit number with both digits restricted to 1, 2, or 3.
JCT(2) has a default of 22.

As both JCT(2) and JCAL(I) can be entered in the PEP input stream, this provides a great deal of flexibility and ease in the choice of correction.

JCT(2) = 11 will result in all corrections, unless otherwise specified, being turned off.

JCT(2) = 33 will result in errors and should not be used.

Any digit of any JCAL(I) that is equal to zero will be replaced by the corresponding digit of JCT(2).

A final scaler, KCAL, is used by PROPCO to determine how corrections to the doppler observable are made when the theoretical doppler value is computed using the phase delay method.

KCAL = $\phi$: Apply corrections to the 2 phase delay calculations before the doppler observable is formed from them.
1: Apply corrections to the doppler values after it has been calculated from the 2 phase delays.

The default is KCAL = $\phi$.

For examples of the use of the PROPCO package, see Appendix A.

## IV. Caveats and Warnings

Some caution must be exercised when the PROPCO package is used. Things that one must be aware of are as follows:

1. PROPCO and the associated changes are only invoked when ICT(43) = 1. The old code has been untouched.

2. (a) When the PROPCO package is used, ICT(22) and (23) no longer control atmospheric corrections.
   (b) ICT(24) = N was never coded in the old code, still has not been coded, and has the same effect as ICT(24) = -1. The documentation in PRMRED has been upgraded to reflect this.

3. When filling the CAL vector using an external program,

   By convention TMDLY units are seconds (of range).
   DOP units are not Hz but Hz/frequency.

4. PRMTER(60)&(61) still have a default of zero. For MEDIA to have non zero correction one of these must be set in the PEP input stream.

5. ATMION and MEDIA have been changed so that they return the value of the correction in the subroutine call. Formerly, they also applied the correction.

6. When calculating the doppler observable by the phase delay method, the correction to the observable can be applied in two ways:

   (a) Correct the plasma delay at the beginning and end of the count inter
   units of correction are in sec.) (KCAL = 0)
   (b) Correct the final value of the doppler shift (units are in Hz/send frequency). (KCAL = 1)

   For externally supplied doppler corrections, KCAL =1 must be used if the phase delay method of doppler calculation is elected.

   For corrections calculated internally by PEP, phase delay dopple corrections differ slightly from instantaneous frequency doppler corrections, and so the residuals will differ slightly between the two uses.

7. Serious errors will result if either of the two significant digits of JCT(2) is zero. In the future, the code will check that this condition does not exist.

## V. Testing

It is well known that debugging is one of the most time consuming and important parts of software production. It is especially important for code, such as PROPCO, that is intended to replace code in an established program. Therefore much time was spent on PROPCO debugging.

There are two basic things to test for in any new software:

(1) It must obtain the correct result.
(2) It must obtain correct results by following the intended algorithm -- not by a fluke.

The testing of a subroutine package such as PROPCO, while complex, was relatively straightforward. The correct results were exactly known, and the procedure to be followed was simple and entirely fixed by the inputs. Three separate testing areas applied:

(1) Its program structure was followed through by using the JCT(3) -2 printout option for cases of virtually every option availa
(2) The new features of the code -- most particularly the abilit to add corrections external to PEP -- were checked by manual obtaining corrections written onto an OBSLIB tape by Bob Goldstein's SXCAL program, manually adding them to Viking residuals with no corrections applied, and verifying that this = the residuals where corrections were applied through PROPCO.
(3) The compatibility of the old and new code was extensively checked.

PROPCO vs. Old Code

| | | RADLND | RADSB |
|---|---|---|---|
| Time Delay | No correction | x | x |
| | ATMION + MEDIA | x | x |
| Instantaneous Doppler | No correction | x | x |
| | ATMION + MEDIA | x | x |
| Phase Delay Doppler KCAL = 0 | No correction | x | x |
| | ATMION + MEDIA | x | x |

Phase Delay Doppler - KCAL = 1; works for corrections external to PEP.

## VI. Technical Details

### 1. Commons

A new labeled common block, called PRPGAT, has been created to store the CAL vectors, the JCAL user input vector, and various other variables.

Common /PRPGAT/

```
      COMMON /PRPGAT/ NCAL,ICUM,KCAL,PARITY(2),CAL(100),SCAL(100),
     1   ICAL(100),JCAL(100),USECO1(100),USECOR(100),CALCOR(100)
      REAL*4 CAL,SCAL
      INTEGER*2 ICAL,KCAL,JCAL,NCAL,ICUM
      LOGICAL*1 USECOR,USECO1,CALCOR,PARITY
```

This common is devoted entirely to PROPCO, and contains virtually all the information needed by PROPCO.

The only other commons block changes are in common /PHADEL/, where 2 real *4 arrays, TCAL1 and TCAL2, and one scalar, TT, were added, as these variables had to do with phase delay doppler corrections only.

### 2. READS & WRITES

The CAL vectors are read from the OBSLIB tape type 4 record by subroutine OBSRED and written onto tape by subroutine COMRIT. The new type 4 record WRITE (READ is similar) is:

```
      WRITE(IABS2)  NCODE,IHR,IMIN,SEC,(RESULT(J),ERROR(J),J=1,2),
     1ATUTS,UTUTS,CLAMP,LIMB,OBSERV,IMONTH,IDAY,IYEAR,JDS,JD(1),CTAT
     2CTRECF,NUMSAV,(SAVE(I),I=1,NUMSAV),NUMOBS,NUMPAR,((DERIV(I,J),
     3I=1,NUMPAR),J=NUM1,NUM2),ILOT1,ILOT2,ILOT3,ILOT4,ILOT5,ILOT6,
     4 NMP2,((DVX(I,J),I=1,NMP2),J=1,NUMOBS),
     5 NCAL,(CAL(I),SCAL(I),ICAL(I),I=1,NCAL),IZERO
```

Line 5 of this write is given over to the new CAL vectors.

### 3. JCT(3) printout control

```
JCT(3) = 3 PRINT OUT THE TOTAL VALUE OF THE
           CORRECTION APPLIED IN PROPCO
JCT(3) = 2 PRINT OUT THE VALUE OF THE MAJOR CORRECTION IN PROPCO
JCT(3) = 1 PRINT THE ICAL AND CAL OF EVERY CORRECTION APPLIED
           IN PROPCO
JCT(3) = 0 PRINT NO PROPCO INFORMATION (DEFAULT)
JCT(3) = -1 PRINT USCO1 IN USCOSU
JCT(3) = -2 PRINT USCO1/USECOR/CALCOR/ICAL/CAL AS THESE
            VECTORS ARE FOUND OR READ IN
     NOTE : JCT(3)=-2 USES A LOT OF PAPER
```

JCT(3) = 1,0,-1, or -2 are useful as debug but JCT(3) = 2 will give the argument of the largest correction applied. Users with extern corrections would be advised to use JCT(3) = 2 to determine if these corrections are being applied correctly.

JCT(3) = 3 prints out the summation of corrections actually applie Of course, if only one correction is applied, JCT(3) = 3 and JCT(3) = 2 will be identical.

JCT(3) = 3 can be used for monitoring corrections, or as an absolute check on the size of the entire correction (if one suspected PROPCO corrections of causing large residuals, for example).

## 4. Changes in PEP Routines

| | | |
|---|---|---|
| 1. | PRMRED | Comments expanded and updated<br>JCAL, KCAL } defaulted to zero<br>NMLST1 expanded to record JCAL and KCAL<br>USCOSU called. |
| 2. | RADAR | Call to PROPCO added. |
| 3. | PRPZRO | Zeroes all or part of the CAL vectors.<br>Used to initialize. |
| 4. | RAD Routines | Unchanged |
| 5. | PROPCO | Essentially totally changed.<br>Old version totally replaced.<br>Handles all radio tracking corrections. |
| 6. | OBSRED | CAL vectors added to OBSLIB tape read |
| 7. | COMRIT | CAL vectors added to OBSLIB tape write |
| 8. | ATMION | Control updated.<br>Dummy CALCOR vector written in to make compatible with old code. |
| 9. | MEDIA | Now returns "RTRN" instead of applying it to the observable |
| 10. | DELDOP | Calls to MEDIA updated to make use of RTRN |
| 11. | SBDLDP | |

## 5. The workings of PROPCO

From USCOSU - JCAL, USECO1, Parity obtained

From Obsred - NCAL, CAL, SCAL, ICAL obtained

1. First the observation type is found

   - Instan. freq. doppler
   - Phase delay doppler — from IPCT
   - Ranging

2. Then USECO (Input = observation type) is called

   USECO uses the USECO1 vector, the parity vector and the ICAL vector to fill the USECOR (100) logical array, doing a logical search for the best corrections.

3. Immediately thereafter, CALCO (Input = obs. type) is called.

   CALCO uses the USECOR vector and the JCAL "ones" digit to fill the CALCOR (100) array.

4. If CALCOR (MEDIA) = TRUE then MEDIA is called.

5. If CALCOR (ATM) = TRUE then ATMION is called for the atmospheric correction.

6. If CALCOR (ION) = TRUE then ATMION is called for the ionospheric correction.

7. PROPCO then sums over all corrections and applies those for which USECOR(I) = TRUE.

# APPENDIX A - Examples

## Example 1

JCT(2) has a default of 22
JCAL (1≤I≤100) has a default of 00

Let's suppose that the following is entered on the PEP input stream:

```
JCAL (1) = 11,
JCAL (2) = 1,
JCAL (3) = 10
```

Thus JCAL (4≤I≤100) = 00. In USCOSU, the JCAL vector will be filled in

```
JCAL (1) = 11,
JCAL (2) = 21,
JCAL (3) = 12,
JCAL (I>3) = 22.
```

Thus CAL (1) would not be applied
CAL (2) might be applied, but would not be calculated, thus unless CAL (2) was on the Obslib tape, it would = 0
CAL (3) would not be applied and, being unapplied, would not be calculated.

## Example 2

Suppose you wanted to use corrections 11 & 12 only, with no others.

```
JCAL (11) = 33   in &NMLST1
JCAL (12) = 33
```

## Example 3

Suppose you wanted to use corrections 11 or 13, but not correction 1 or

```
JCAL (1) = 11
JCAL (3) = 11
```

Thus, when correction 11 is available, it alone will be used.

When correction 13 is available, but not 11, only 13 will be used.

When neither 13 or 11 is available, corrections 9 & 7 will be used.

Example 4

Suppose in Input stream

```
JCT (2) = 33
```

and no JCAL's were entered

in USCOSU, JCAL (I>100) would be set = 33,

every correction (up to NCAL) would be applied, in most cases this would be a grievous error.

Example 5

Suppose in Input stream

```
JCT (2) = 11

JCAL (1) = 22
JCAL (2) = 20
```

in this case, USCOSU turns JCAL into:

```
JCAL (1) = 22
JCAL (2) = 21
JCAL (I>2) = 11
```

Thus only CAL (1&2) would be applied.

Moreover CAL (2) = 0 would hold unless it was entered by an OBSLIB tape

Example 6

Suppose that you had corrections 1-10 stored on the OBSLIB tape, and thus wanted to use them but not to calculate them, the proper response to this is

```
JCT (2) = 21
```

Example 7

Suppose you wanted to apply only MEDIA corrections (I=9,10) and none else. There are several ways to do this.

(1) Enter
```
JCAL (9) = 33,
JCAL (10) = 33
```

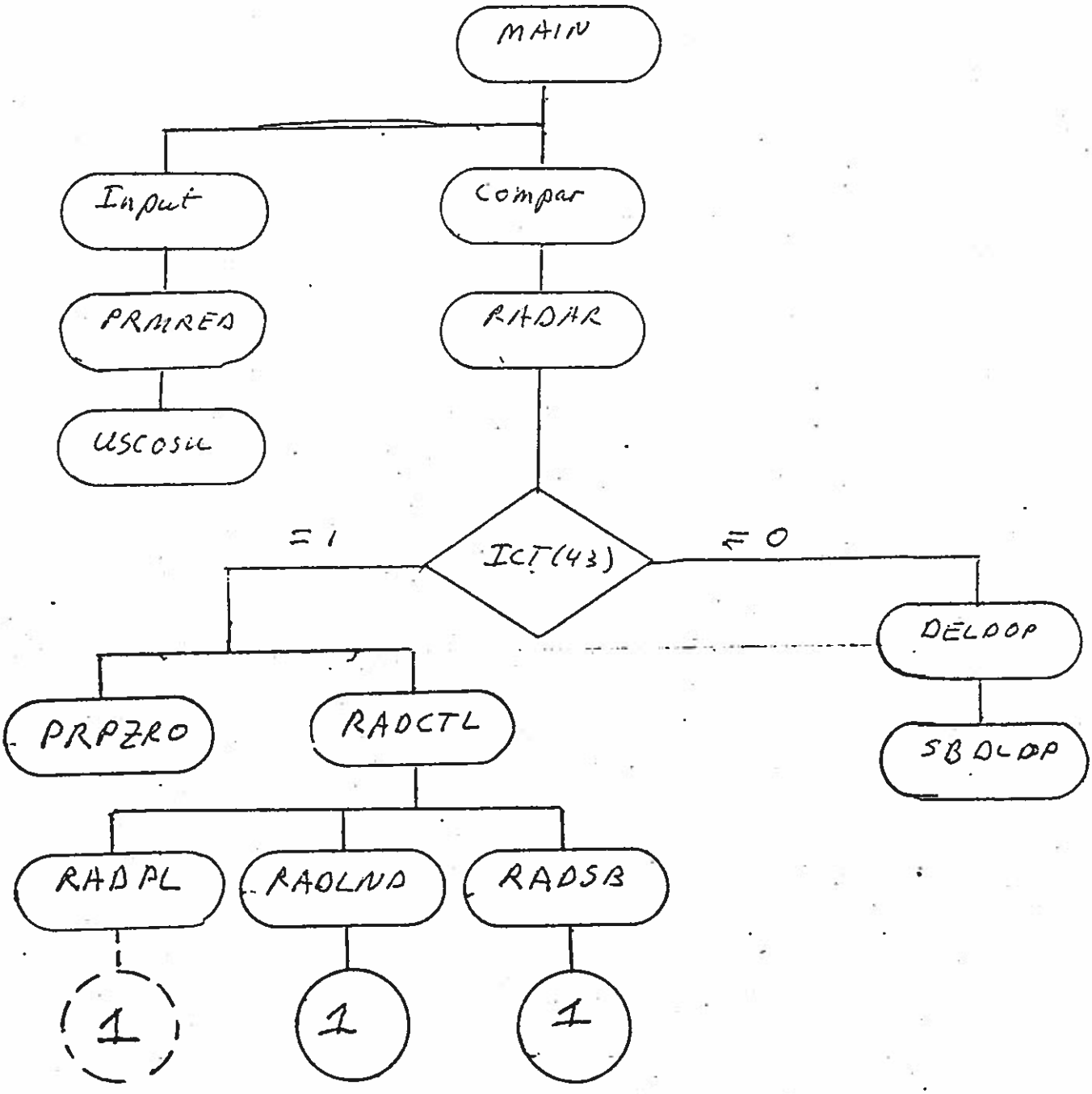
with JCT (2) = 22, this turns off all other corrections.

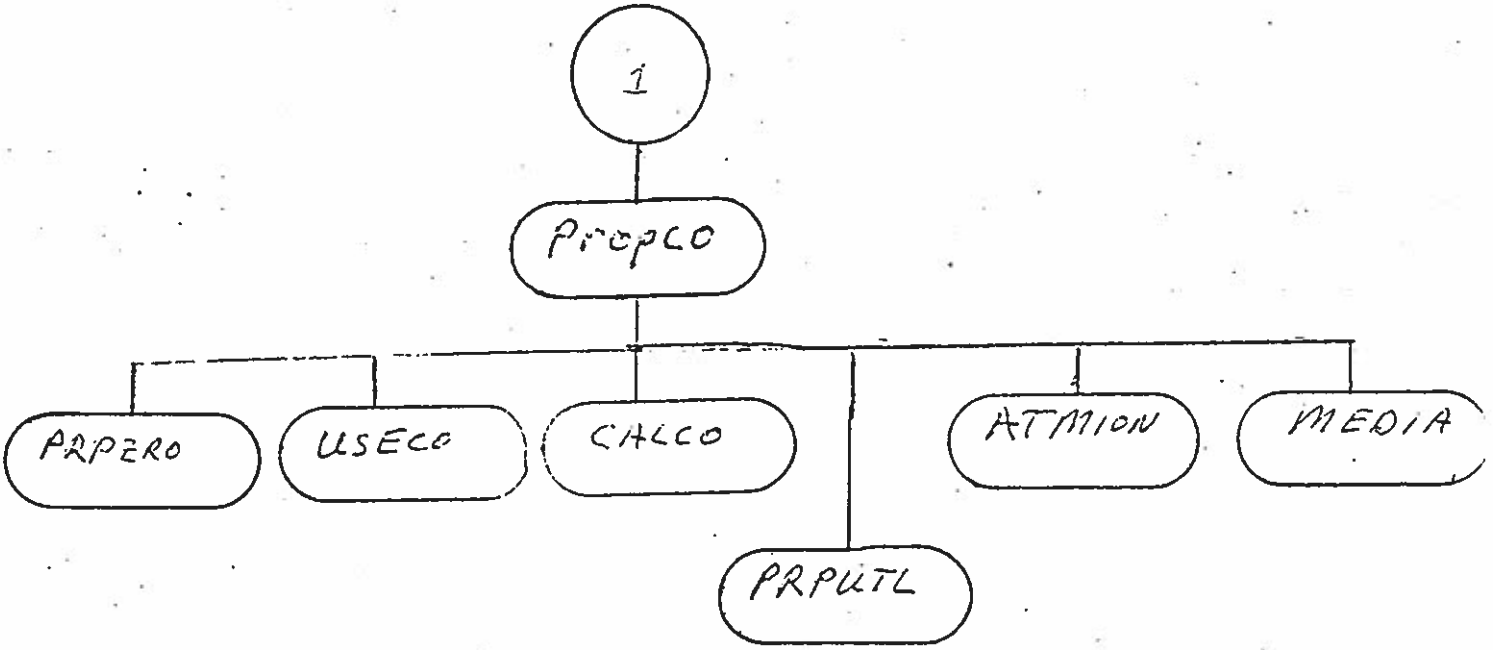
(2) Enter JCT (2) = 11
JCAL (9) = 22
JCAL (10) = 22

with all other JCAL's set = 11, this will have the same effect.

(3) Enter JCAL (1) = 11
JCAL (2) = 11
JCAL (3) = 11
JCAL (4) = 11
JCAL (5) = 11
JCAL (6) = 11
JCAL (7) = 11
JCAL (8) = 11
JCAL (11) = 11
•
•
• until you reach NCAL

This does manually what method (2) does for you.


MAIN
Input
Compar
PRMREA
RADAR
USCOSU
ICT(43)
= 1
= 0
DELOOP
PRPZRO
RADCTL
SBDLOP
RADPL
RADLND
RADSB
1
1
1


1
PropCO
PRPERO
USECO
CALCO
PRPUTL
ATMION
MEDIA