C No. 19 (1993)

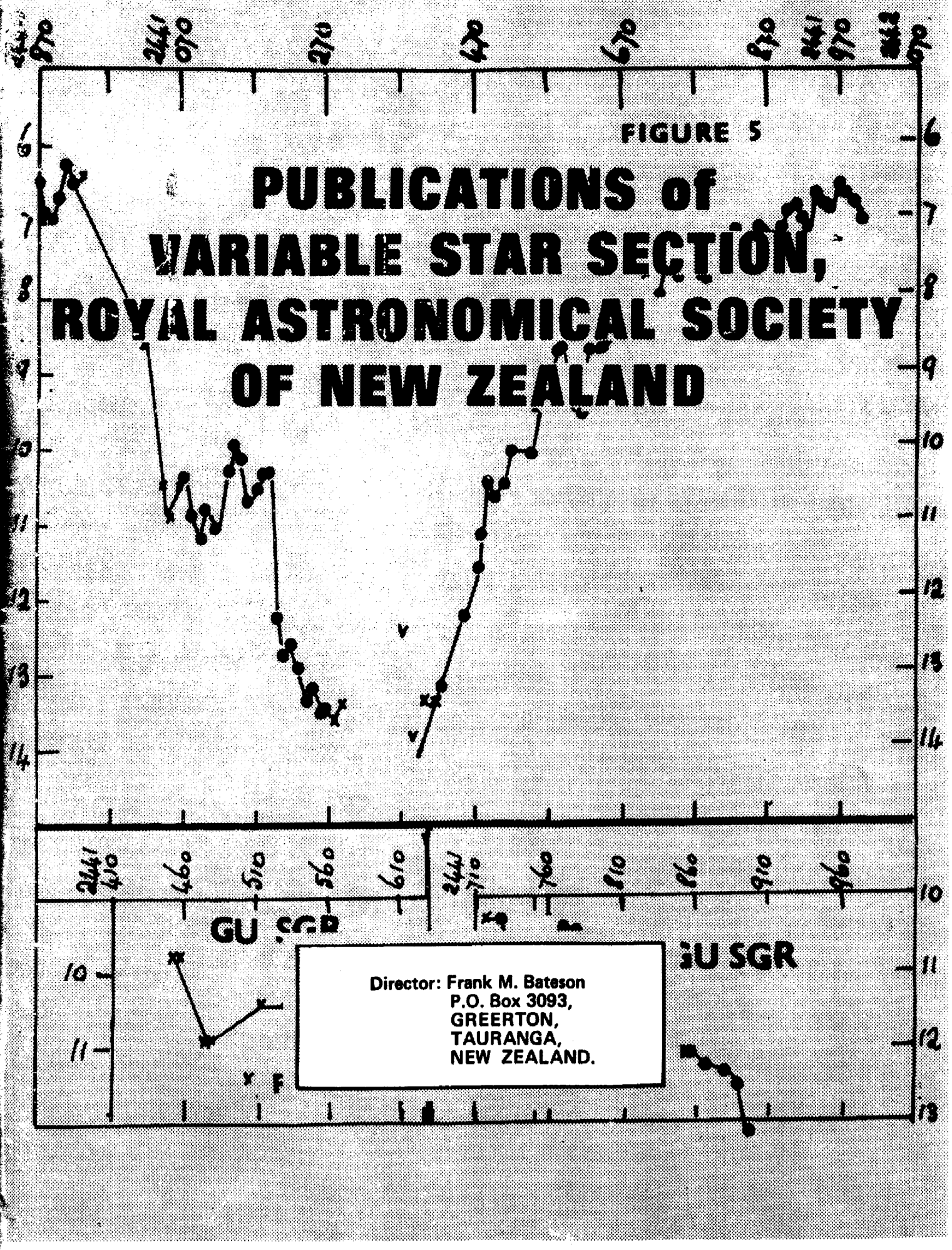


FIGURE 5

# PUBLICATIONS of VARIABLE STAR SECTION, ROYAL ASTRONOMICAL SOCIETY OF NEW ZEALAND

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GREERTON,
TAURANGA,
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ISSN 0111-736X

# PUBLICATIONS OF THE VARIABLE STAR SECTION ROYAL ASTRONOMICAL SOCIETY NEW ZEALAND

## No. 19

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1994 December 1

# E D I T O R I A L

The late printing of this issue has been caused by a change of printers and arrangement of publication dates so that more issues are made each year. We have also awaited the official advice from the Inland Revenue Department that Astronomical Research Limited is now accepted as a Charitable Trust. This advice came today. This means we no longer have to charge New Zealand subscribers G.S.T.

Publication No. 20 which will follow the current issue in three months will consist of the Index to Publications 1 to 19 plus a detailed Index to Charts for Southern Variables, Series 1 to 23. Publication No. 21 also planned for issue in 1995 will have an improved format and continue the publication of a wide range of papers on Southern Variables.

1994 December 1

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# RW SEXTANTIS

## SEQUENCE FOR COMPARISON STARS

A.C. Gilmore
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P.O. Box 57, Lake Tekapo, N.Z.

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Comparison stars for RW Sex were lettered on Chart 913 (1). The field is shown on a larger scale on Chart 1043 (2).

Measures of comparison stars made with the 0.6-m B&C telescope at Mt. John on 1994 March 21 and 22 UT. All stars were measured on the first night and stars down to "H" on the second night.

Measures were made differentially with respect to HR 4060, star "63" on the chart. Its V and colours, as listed in the Bright Star Cataloge are tabulated below. The check star was HR 4042, star "52" on the chart. The BSC values for these stars were fully consistent with the photometry.

| | | | V | B-V | U-B |
|---|---|---|---|---|---|
| HR 4060 | = | "63" | 6.32 | +0.33 | +0.03 |
| HR 4042 | = | "52" | 5.24 | +0.21 | +0.13 |

Each star was measured twice on a night with a sky reading between. The comparison was measured before and after. Below is a summary of the results. "sV", etc., are the standard deviations of the measures. "Nights" gives the number of nights the star was measured. "No." is the number of measures used to calculate the mean magnitude and colours.

| Star | V | B-V | U-B | sV | s(B-V) | s(U-B) | Nights | No. |
|---|---|---|---|---|---|---|---|---|
| "72" | 7.22 | +1.68 | - | 0.00 | 0.01 | - | 1 | 2 |
| A | 7.66 | +0.27 | +0.06 | 0.01 | 0.01 | 0.00 | 2 | 4 |
| B | 8.71 | +1.05 | - | 0.01 | 0.02 | - | 2 | 3 |
| C | 9.26 | +1.33 | - | 0.03 | 0.05 | - | 2 | 4 |
| D | 9.60 | +1.06 | - | 0.02 | 0.02 | - | 2 | 4 |
| E | 10.22 | +0.90 | - | 0.04 | 0.02 | - | 2 | 5 |
| F | 10.29 | +1.13 | - | 0.01 | 0.01 | - | 2 | 4 |
| G | 9.69 | +1.73 | - | 0.01 | 0.02 | - | 2 | 4 |
| H | 11.24 | +0.44 | - | 0.04 | 0.06 | - | 2 | 4 |
| K | 11.26 | +0.59 | - | 0.04 | 0.00 | - | 1 | 2 |
| L | 11.90 | +1.28 | - | 0.00 | 0.02 | - | 1 | 2 |
| M | 11.94 | +0.94 | - | 0.01 | 0.01 | - | 1 | 2 |

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(1) Bateson, F.M. & Morel, M. 1988. Charts for Southern Variables, Series 20. Publ. by Astronomical Research Ltd., Tauranga, N.Z.

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# THE VISUAL LIGHT CURVE OF AG CARINAE 1954 to 1994

Frank M. Bateson
Director Variable Star Section, RASNZ
P.O. Box 3093, Greerton, Tauranga, NZ

SUMMARY: Four decades of visual observations of AG Car shows it spends years varying slightly around magnitude 8.0, or at an intermediate magnitude about 0.5 mags brighter. These long intervals are broken by minor flare ups to magnitude 6.5 and in 1981/82 and 1993/94 by outbursts to 6.0, or slightly brighter. Minor variations may possibly be quasi-periodic but this cannot be definitely established because of the visual appearance of this object where its brightness is estimated with instruments of different aperatures.

- - - - - - -

## 1. INTRODUCTION

AG Car is a supergiant of the S Dor type of C.V.s. Thackeray (1) discovered that it was the central star of a low-excitation planetary nebula and had a P Cyg spectrum.

In a later paper Thackeray (2) gave a more detailed description of the spectrum. Spectral observations obtained in February 1977 by Hutsemekers & Kohoutek (3) were made during a relatively inactive phase (V = 7.6). They state their data implies the presence of a low density shell expanding at about 200km/s. Their paper includes the VSS, RASNZ light curve between 1969 and 1985. They suggest that in intervals of intermediate luminosity small amplitude (0.5 - 1 mag) may possibly have a quasi-period of about 700 or 350 days.

## 2. OBSERVATIONS

Visual observations by the Variable Star Section, Royal Astronomical Society of New Zealand, commenced on J.D. 2,434,747 (January 4, 1954). The charts for AG Car are Nos. 452/3 (4) which show V mags. for the comparison stars.

## 3. THE LIGHT CURVE

Figs. 1 to 8 show the light curve from individual observations from J.D. 2,434,747 to 2,449,385 (February 1, 1994). Attention is drawn to the interval J.D. 2,434,747 to 2.438,105. (Figs. 1 & 2) because it demonstrates the best method for visual observers by which to observe a difficult object. The estimates in this interval were made by A.F. Jones and F.M. Bateson.

Jones made almost all his observations with a 4.5cm finder while all Bateson's estimates were made with a 20cm refractor using a power of 54x. Rarely did either observe in moonlight

or when there was twilight. Ninety per cent of all observations were noted as Class 1, i.e. reliable and without hindrance from cloud. The agreement between the two observers is good.

There were slight variations around a mean magnitude of 7.8 until J.D. 2,435,483 when there was a sudden fading to 8.9 preceding a slow fading to a mean of 8.2. AG Car remained at this brightness with very slight fluctuations until the end of this interval.

Thereafter estimates were made by many observers, whose numbers have increased in more recent years. Many were experienced visual observers whilst others were beginners who gained in experience and skill with time. These circumstances meant a great deal more scatter in the data than was desirable. The main reasons for this were the different aperatures used and the fact that many observations were class 2, due to hindrance from moonlight, cloud or haze. A contributing factor was that some observers kept switching instruments, some times using binoculars, small aperture finders or their main telescopes with apertures ranging from 15 to 30cm.

My experience is that objects such as AG Car should always be measured by an observer with the same instrument. Binoculars are not suitable and, as far as possible, estimates should not be made in moonlight.

## 4. DISCUSSION

AG Car has the following states of activity:

(A) Major increases in brightness to mag. 6.0 or slightly brighter. These occurred in 1981/82 and 1993/94. The latter has continued at least to June 1994. Rise comparatively steep and the decline very slow often lasting many months or even years.

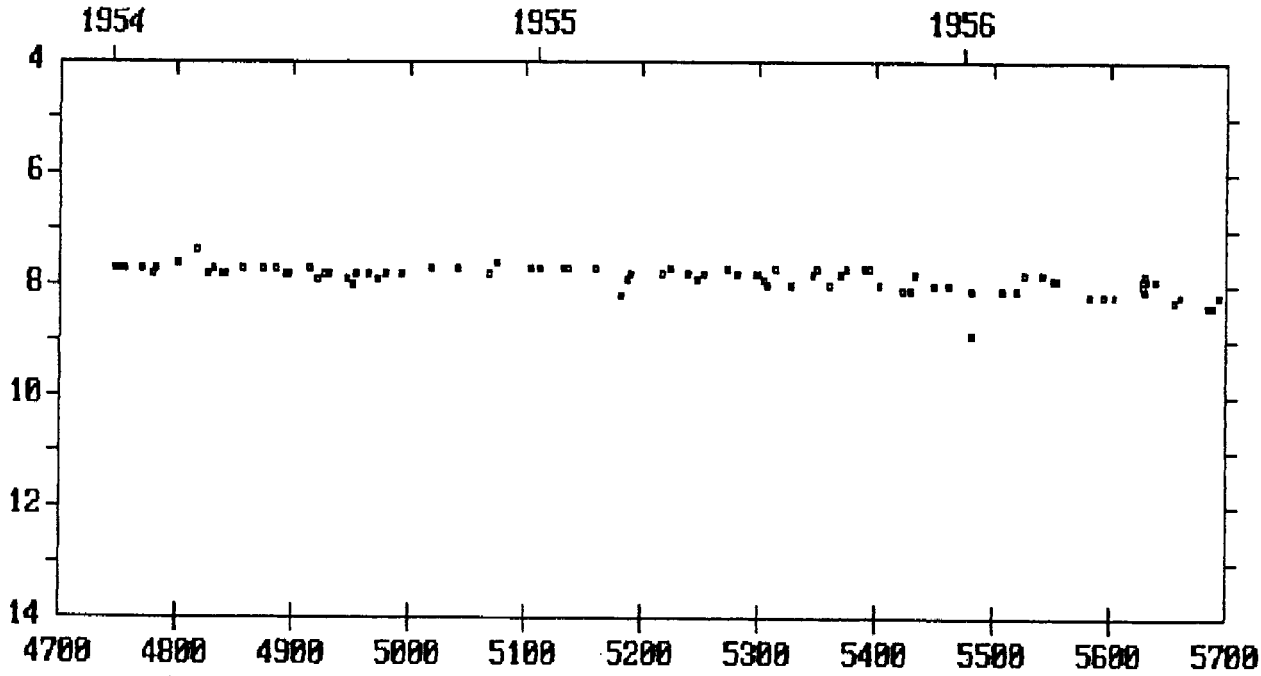
(B) Mean brightness increases to mag. 6.5 - 7.0. The rise is short with the variable remaining at this brightness for years followed by a slow decline. This occurred in 1965/1967.

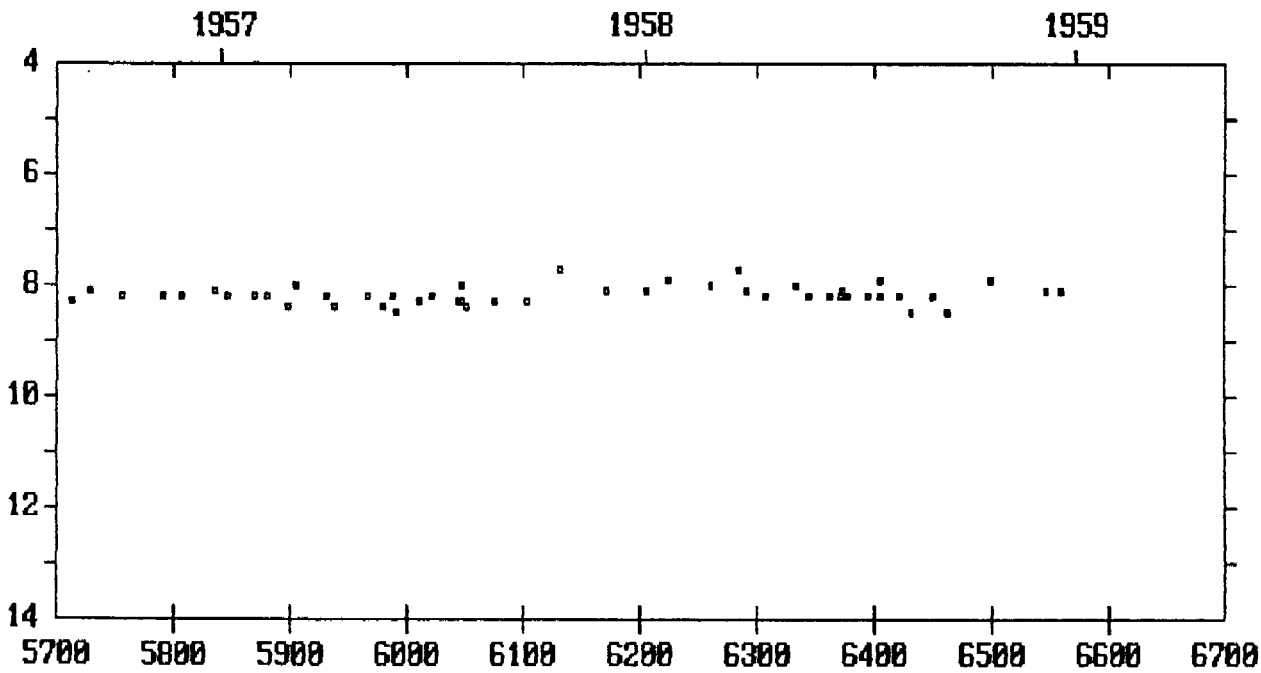
(C) Intervals of comparative inactivity around magnitude 7.6 There appears to be slight irregular variations with a gradual decay to state D.

(D) Intervals, usually lasting several years, when AG Car remains at mag. 8.0 or slightly fainter with any small fluctuations masked by the scatter in the estimates.

Variations at all phases must be regarded as irregular despite the possibility that at times they may have a quasi period. Proving or disproving this would involve evaluating each estimate and plotting only those regarded as first class. This can hardly be justified and could well be biased.

AG CARINAE



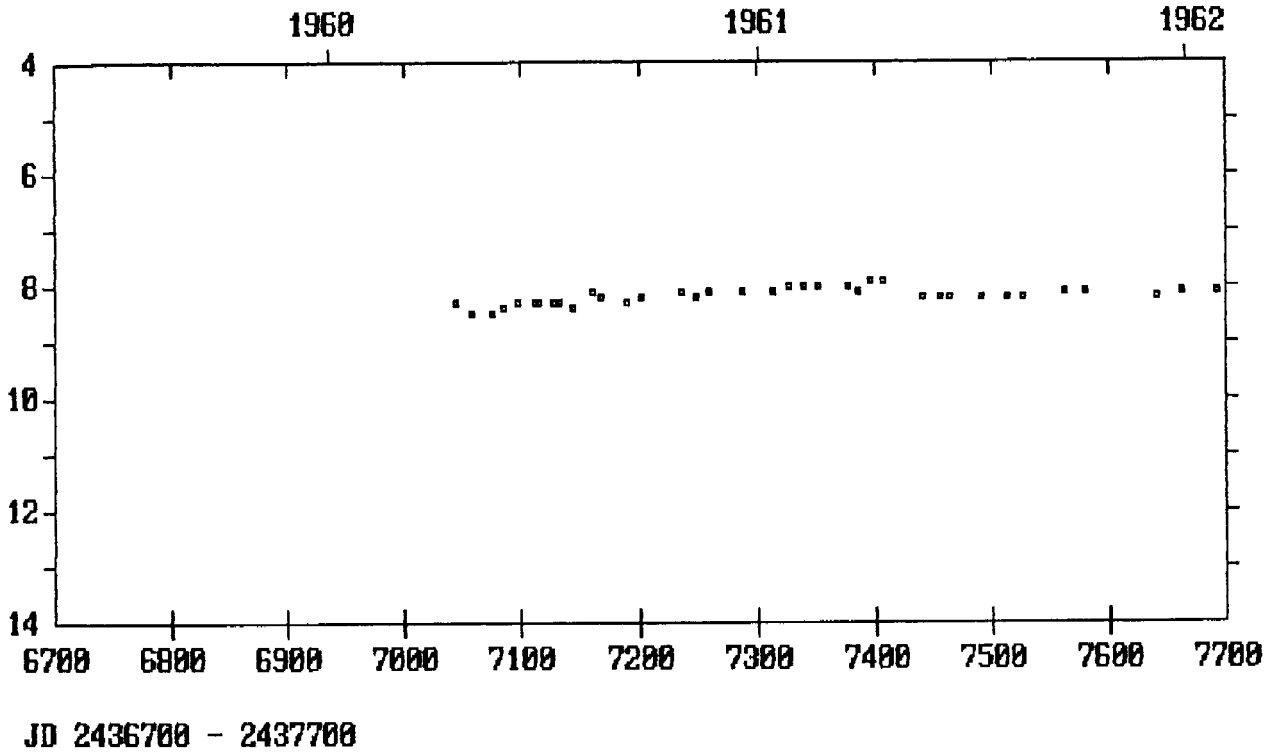

AG Car

FIGURE 1

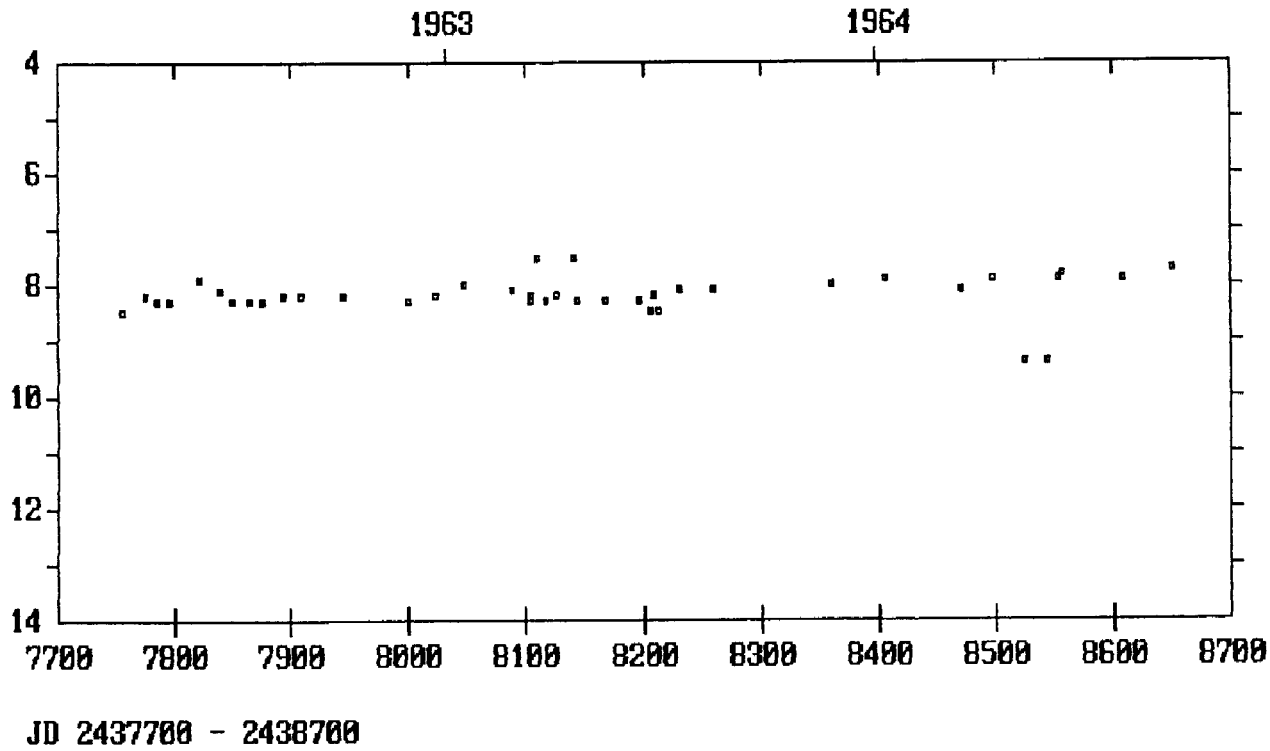
LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,434,700 - 2,436,700

6. 105259 AG CAR



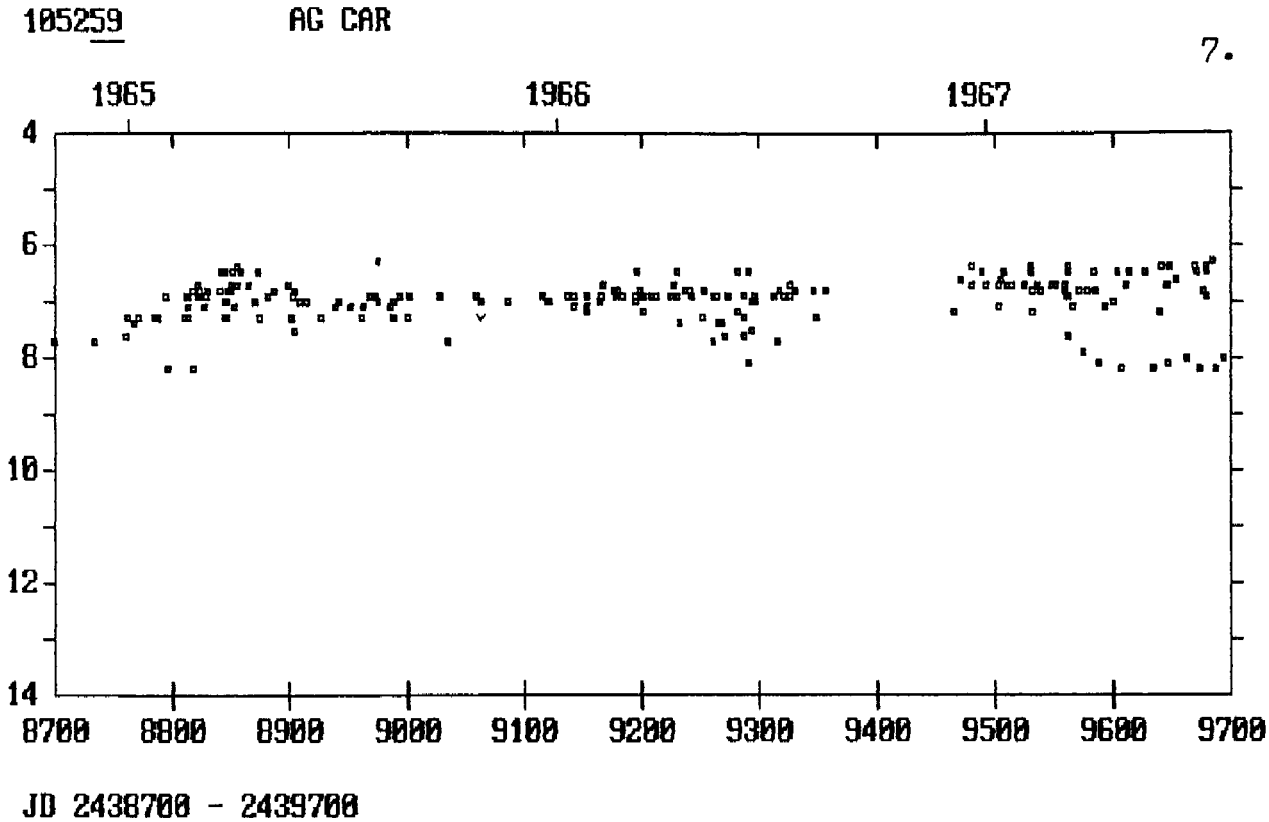

105259 AG CAR

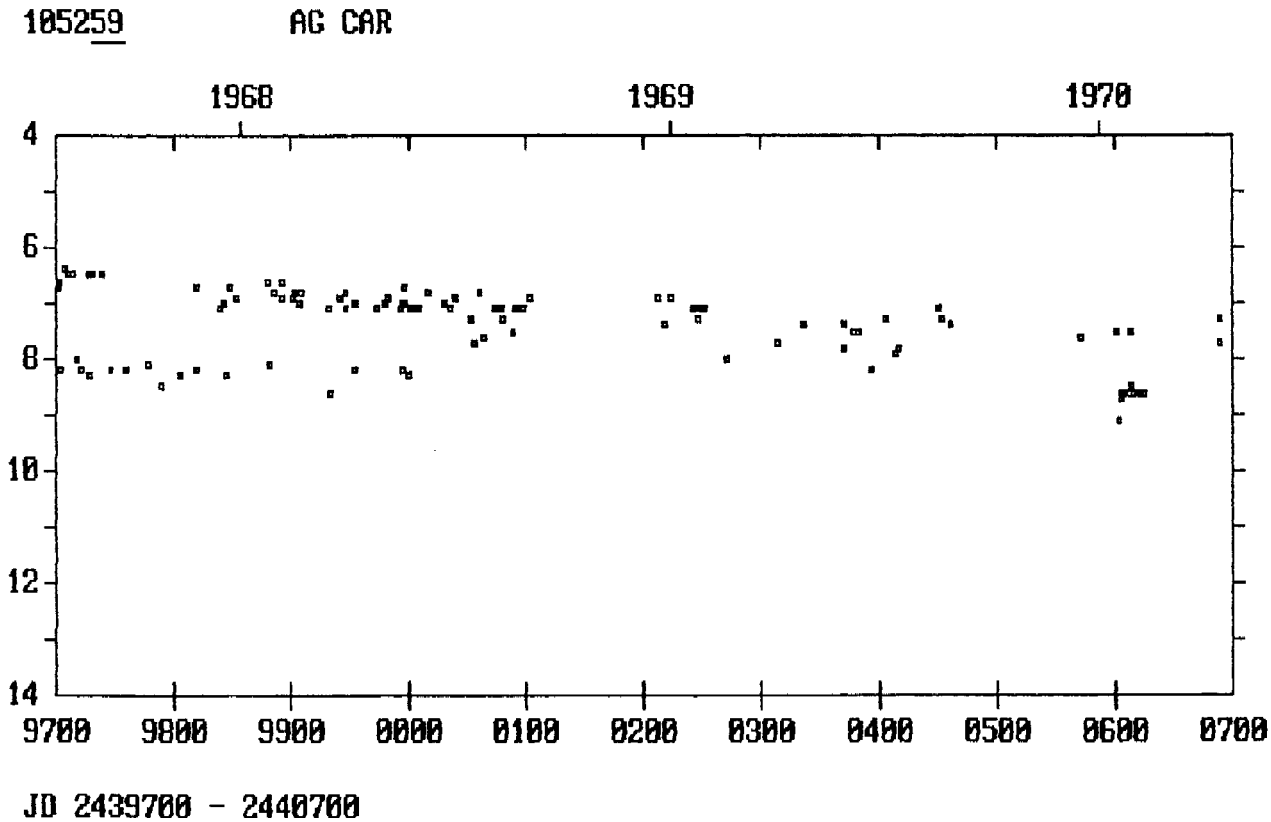



AG Car FIGURE 2

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,436,700 - 2,438,700

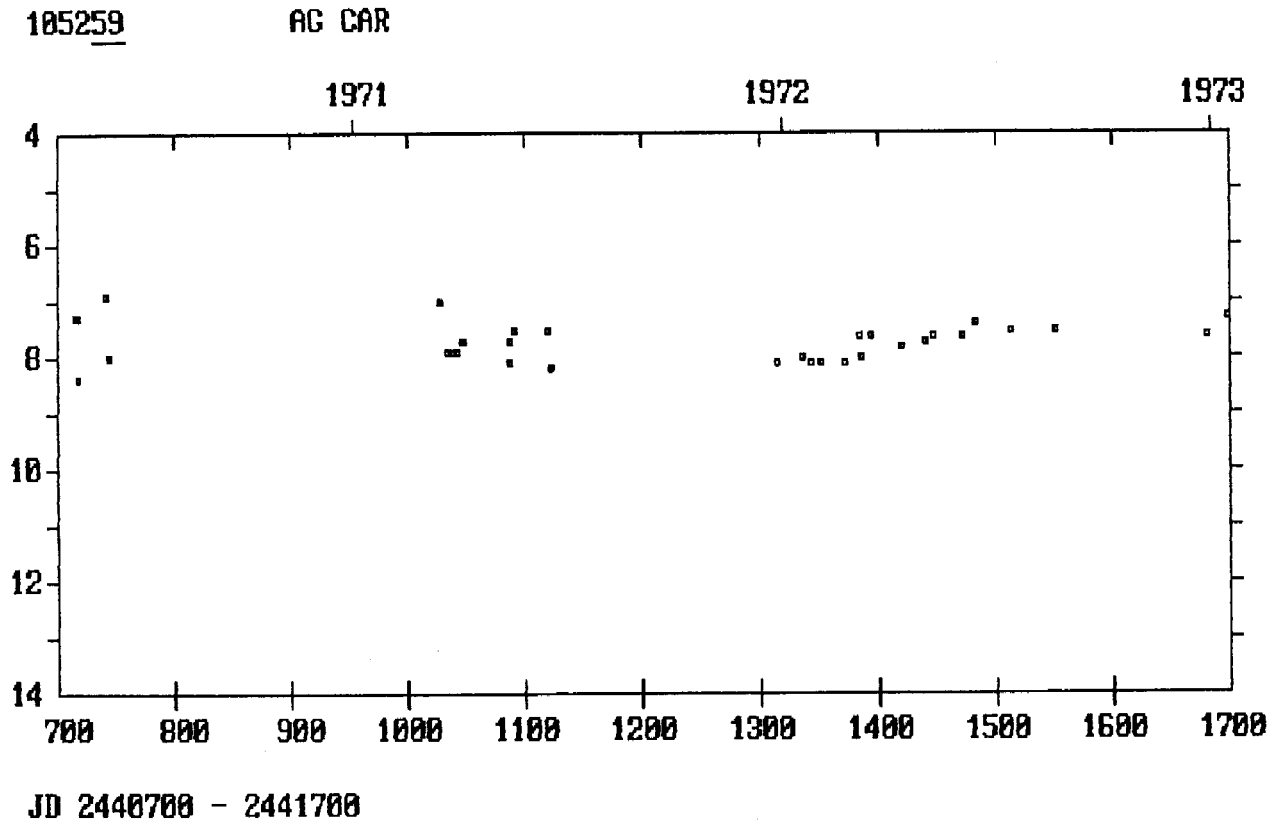


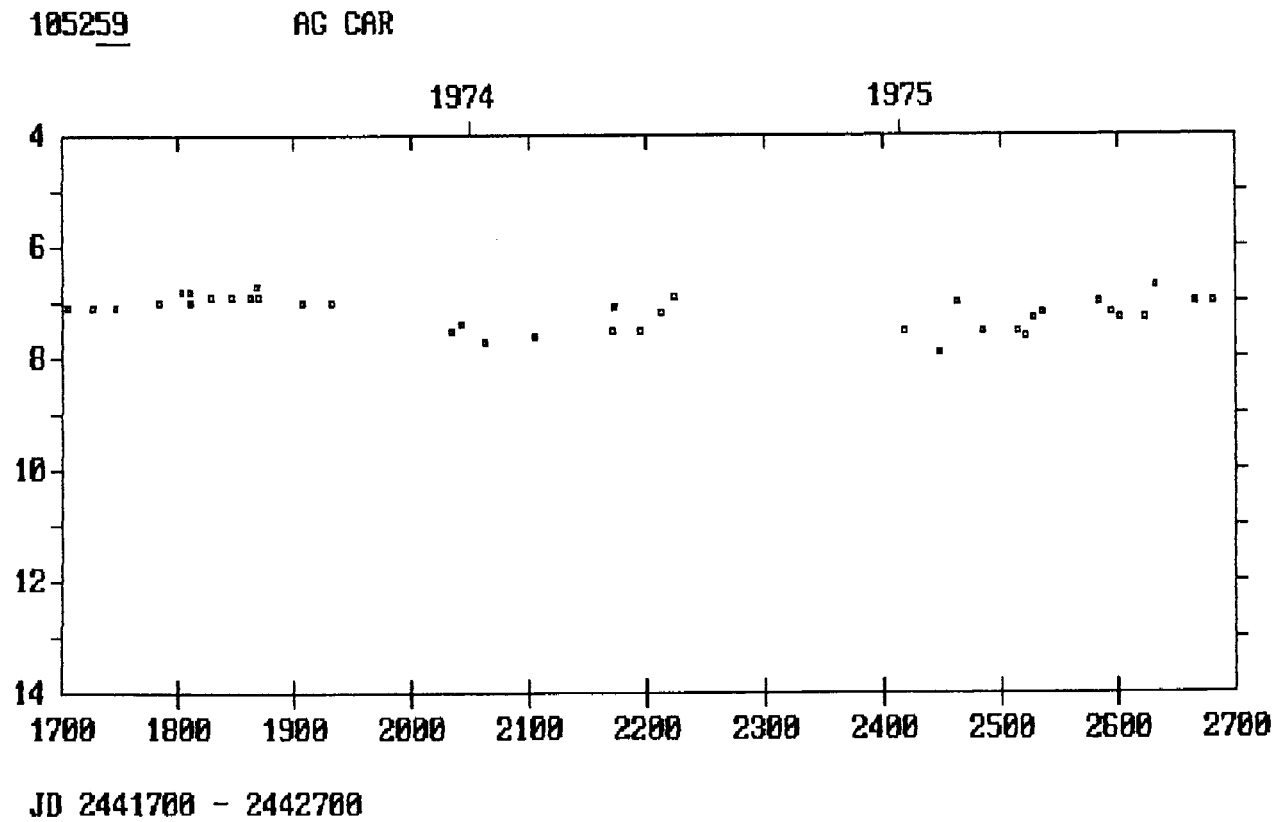




AG Car FIGURE 3

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,438,700 - 2,440.700



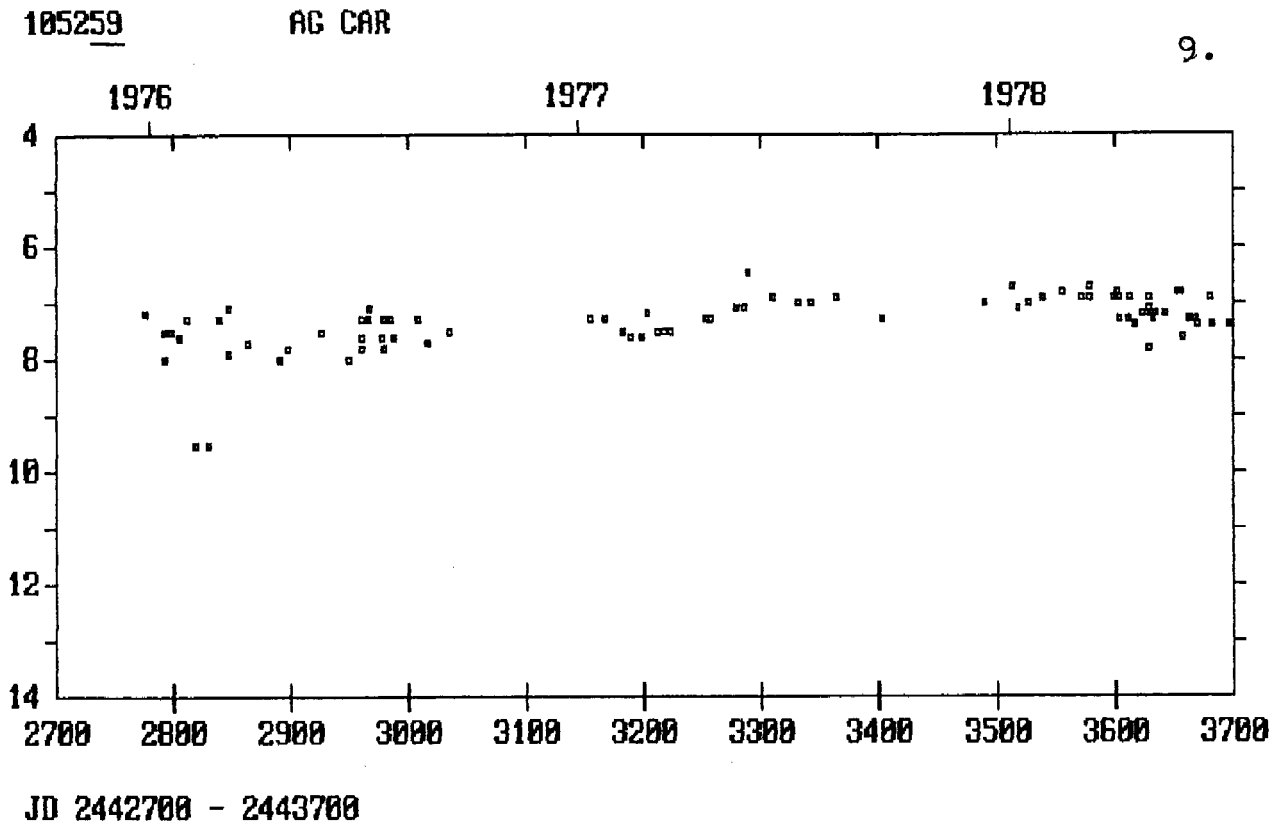



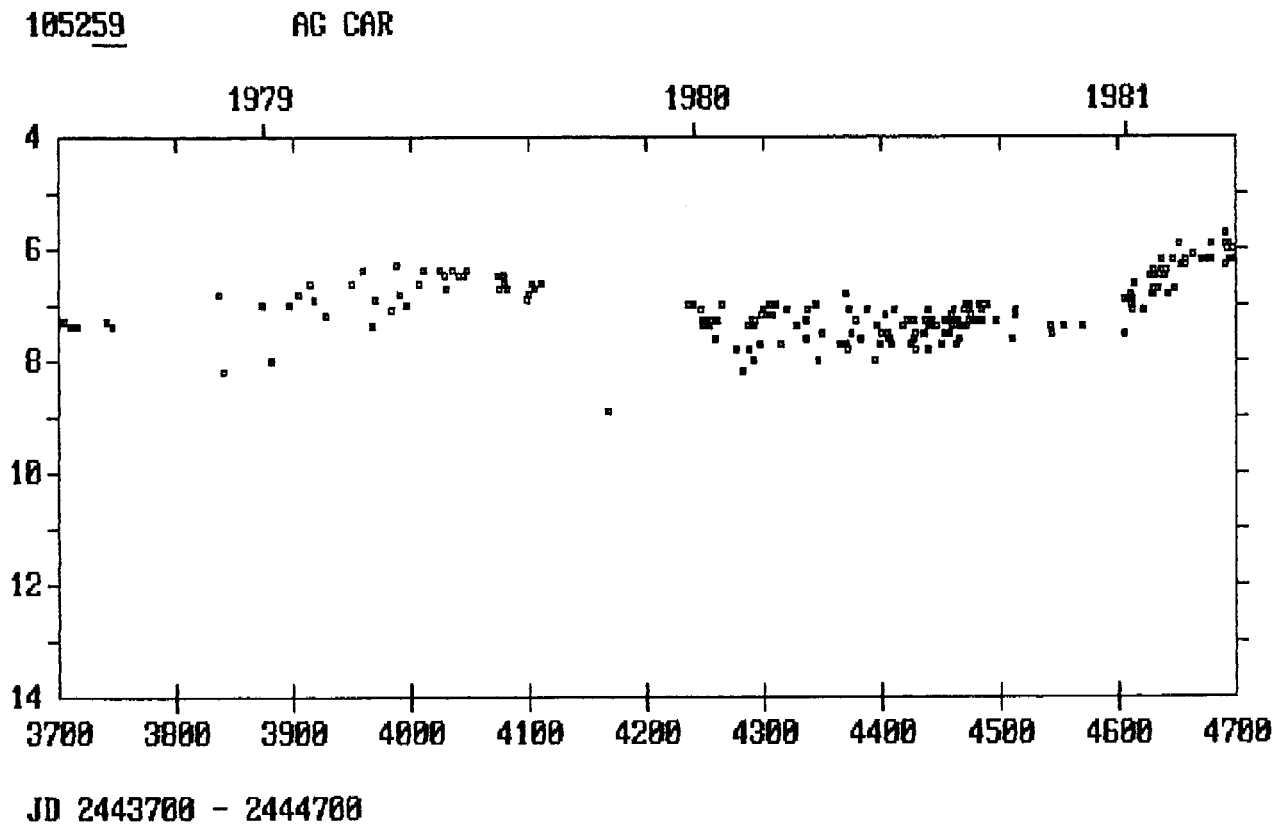

AG Car

FIGURE 4

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,440,700 - 2,442,700

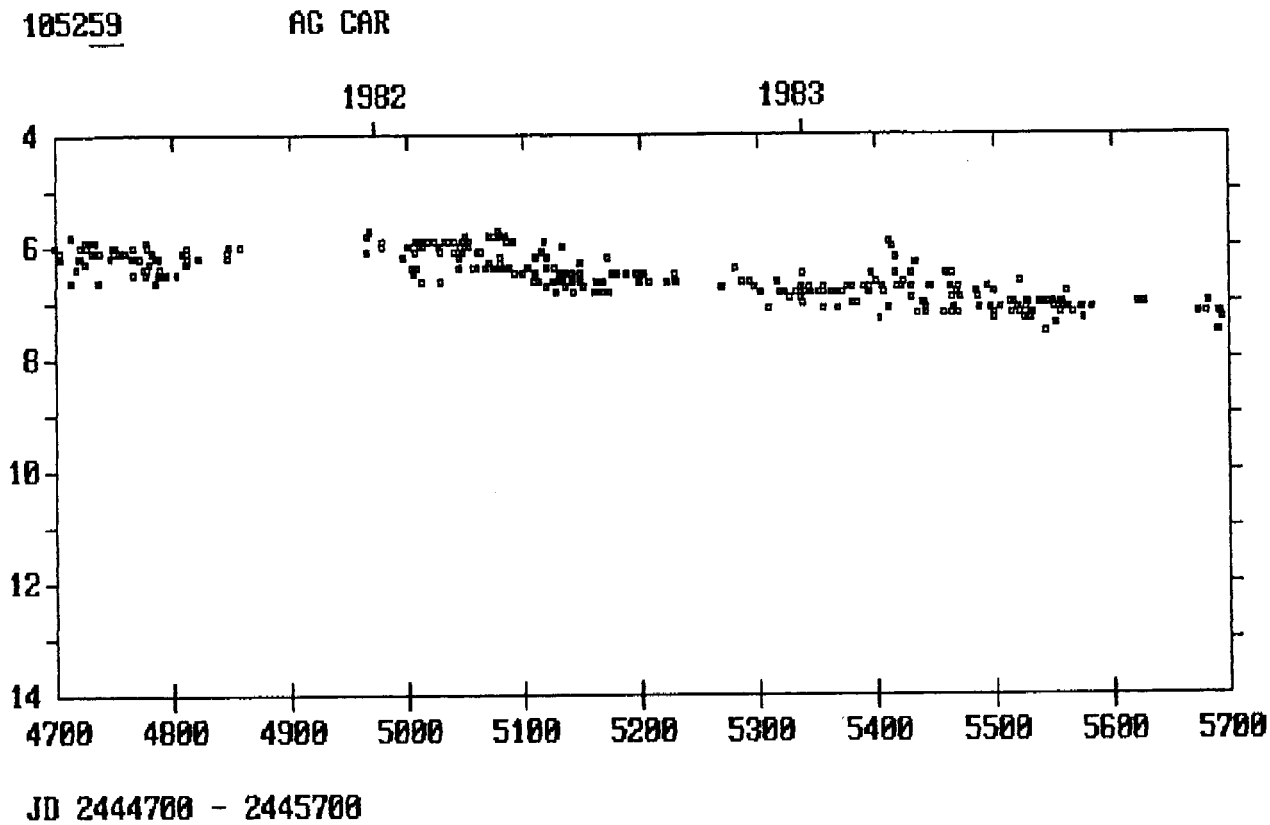


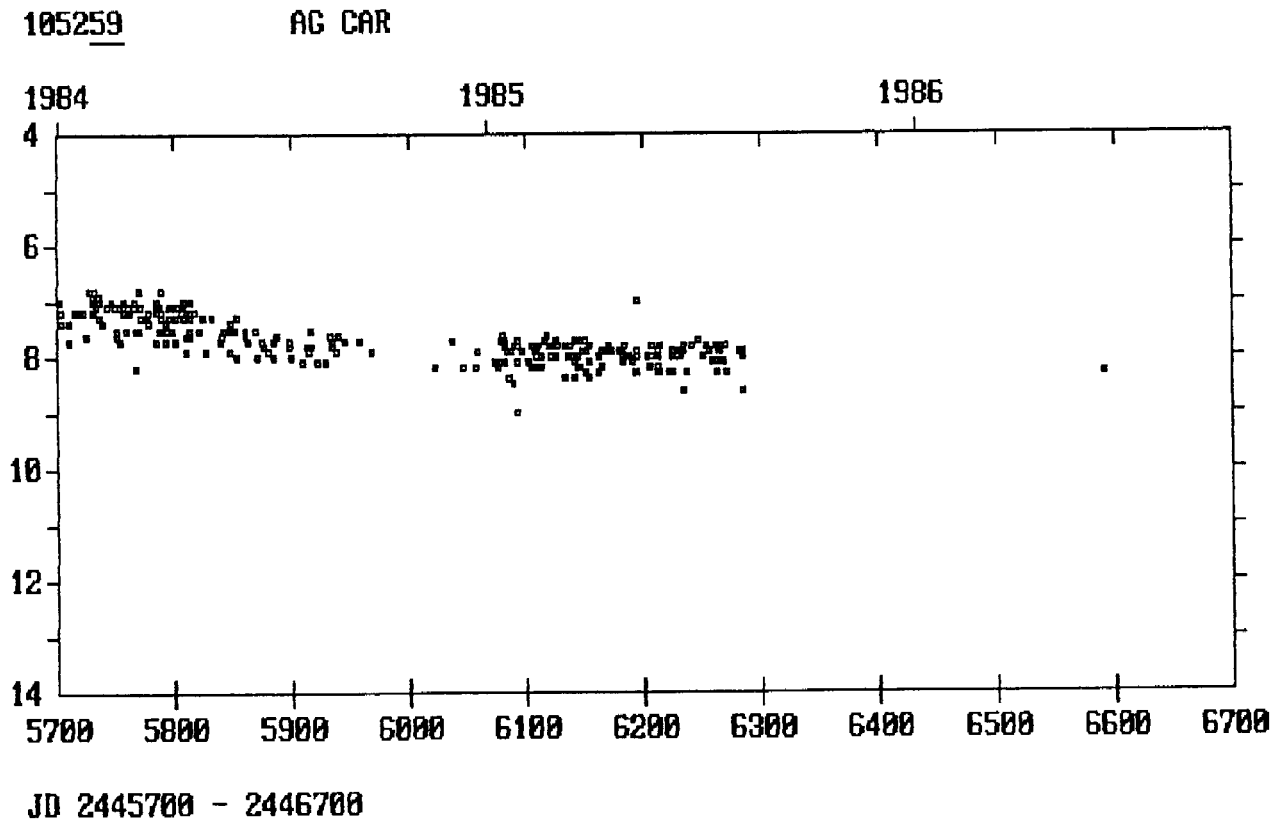




AG Car FIGURE 5

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,442,700 - 2,444,700



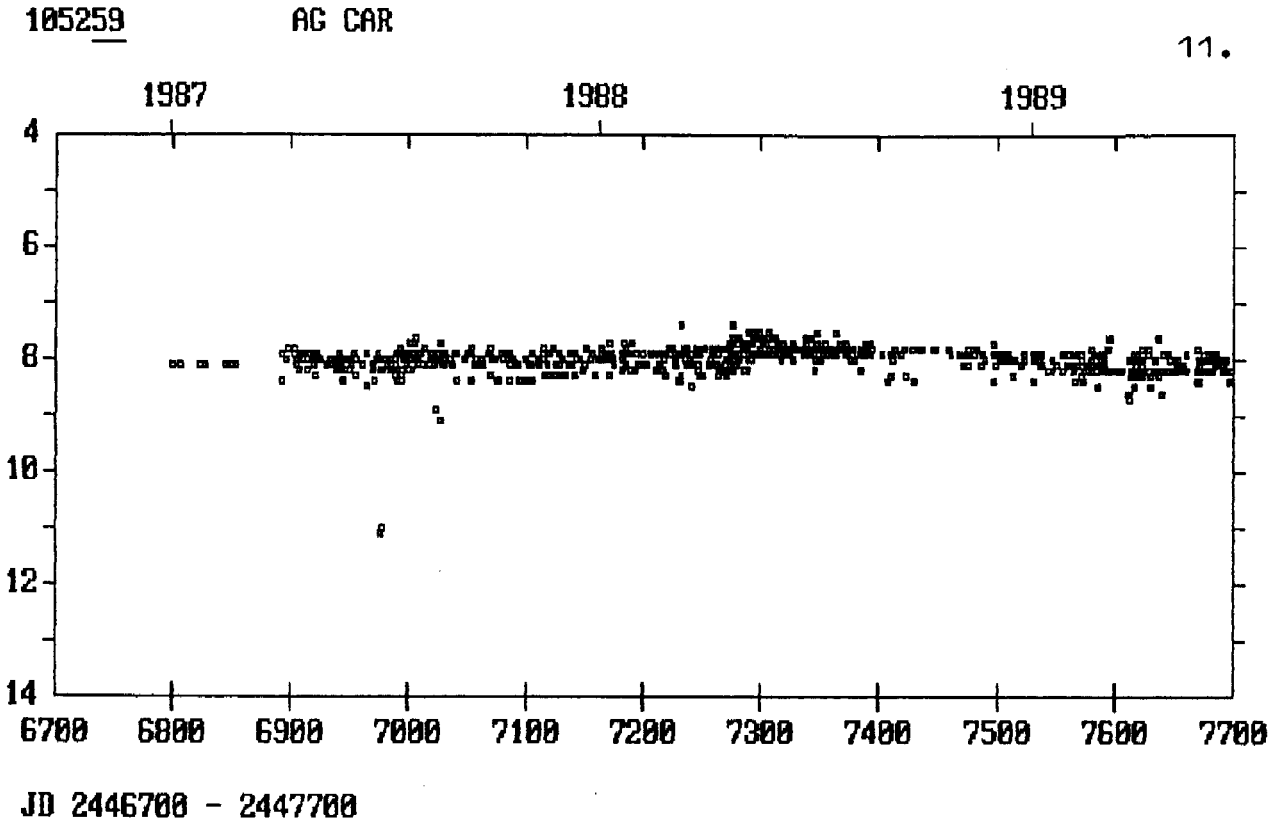



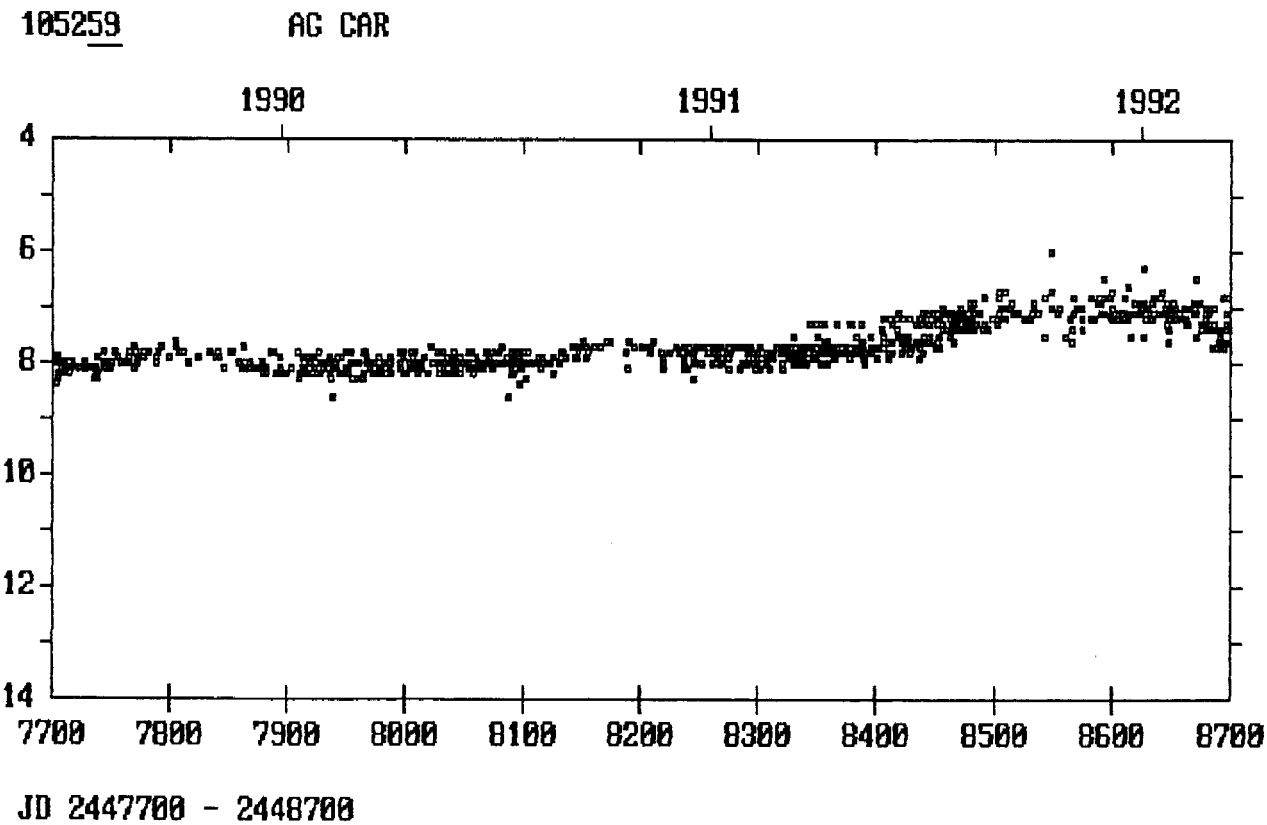

AG Car

FIGURE 6

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,444,700 - 2,446,700

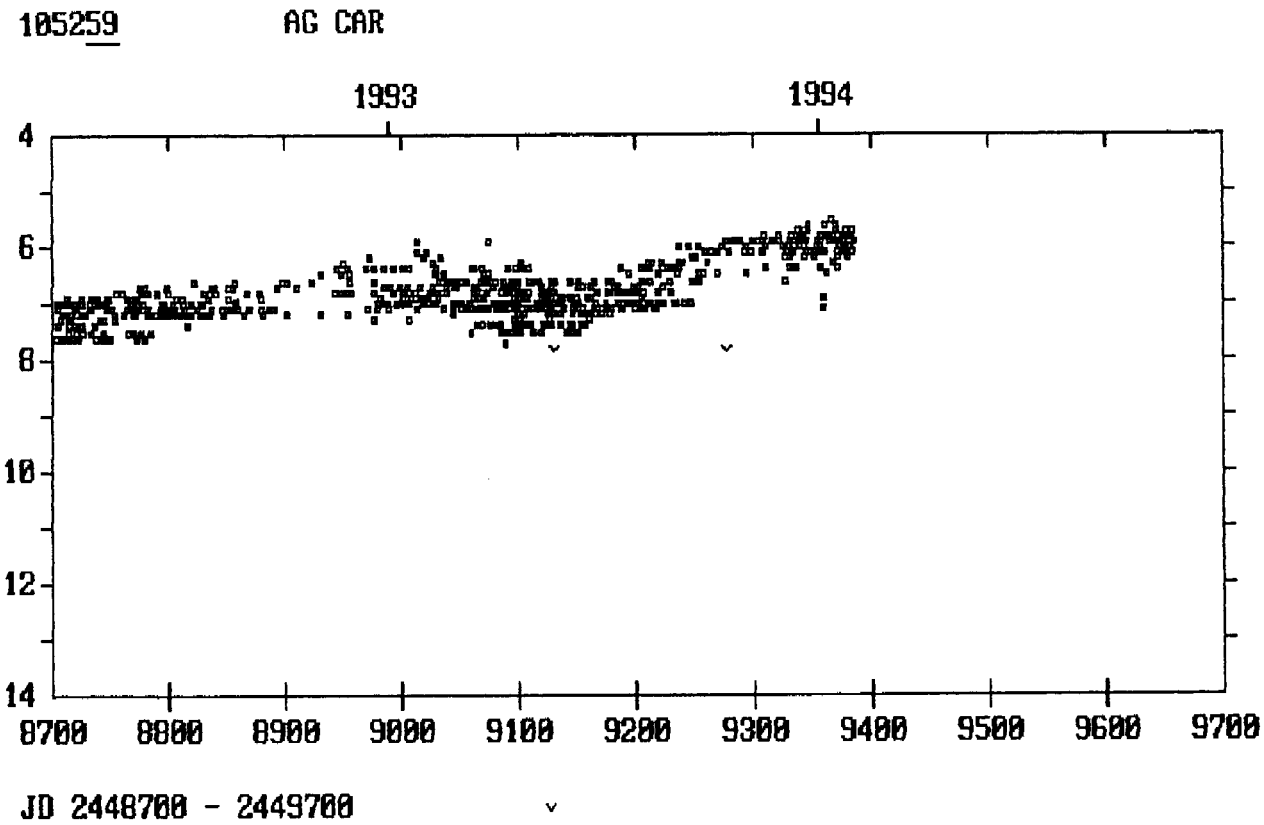



AG Car FIGURE 7

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,446,700 - 2,448,700




AG Car FIGURE 8

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS
J.D. 2,448.700 - 2,449,385

. . . . . .

AG CARINAE 1954 to 1994 (Cont.)

AG Car may possibly end some day as a supernova or perhaps exhibit the same brightness changes as Eta Car has done in the past. It therefore should be closely monitored following the suggestions made in Section 4 of this paper.

It is concluded that AG Car has four stages of activity and that minor variations occur irregularly.

ACKNOWLEDGEMENTS

Ranald McIntosh was responsible for the computer light curve and Don Brunt for processing archival observations. Observations were made by almost every member of the Variable Star Section, RASNZ and without their data this paper could not have been written.

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(2) Thackeray, A.D. 1977. Mon. Not.R.astr.Soc.180,No.1,p. 95-102
(3) Hutsemekers, D. & Kohoutek, L.1988. Astron. Astphys. Supl. Ser. 73, pp. 217-224.
(4) Bateson, F.M., Morel M., Sumner B, & Winnett R.D. 1979. Charts for Southern Variables, Ser. 11.

# REVISED SEQUENCE FOR V821 CENTAURI

Grant Christie
27 Liverpool Street, Epsom, Auckland

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V821 Cen = HD 124448. Charts 652/3 (1) were issued under the star's HD number when it was a suspected variable. Later it was given an official designation after variability had been confirmed. A sequence of V magnitudes was published with the charts.

Frank Bateson, after comments from several observers that some of the sequence magnitudes appeared too bright, requested that they be remeasured. Johnson UBV measurements were made on three nights using the photometer at Auckland Observatory.

Concerns about the original sequence were obviously well founded, several being in error by over 1 magnitude. The comparison stars were remeasured on J.D. 2,449,502, 2,449,505 and 2,449,507 (mean time was J.D. 2,449,504.71) with the Winstone Blackwell 0.5m telescope at Auckland Observatory. The photometric system (standard UBV filters and an uncooled EMI9502 photomultiplier) had recently been recalibrated using Menzies et al, E region standards (2). The primary comparison star used was HD 125442 with V, B-V and U-B values from Cousins and Stoy (3). The check star used was HD 125238 for which the listed values (3) are:

| Source | V | B-V | U-B |
|---|---|---|---|
| Ref. (3) | 3.53 | -0.18 | |
| Ref. (3) | 3.56 | -0.20 | -0.71 |
| Auckland Obs. | 3.55 | -0.16 | -0.65 |

The agreement here is quite acceptable for our present purposes. The revised sequence for V821 Centauri is:

| Star | V | B-V | U-B |
|---|---|---|---|
| "63" | 6.30±0.006 | 0.59 | 0.08 |
| "c" | 9.09±0.02 | 0.47 | 0.05 |
| "d" | 9.29±0.005 | 0.40 | 0.07 |
| "g" | 9.93±0.03 | 0.30 | 0.17 |
| "105" | 10.49±0.04 | 1.17 | 1.38 |
| "f" | 9.28±0.04 | 1.03 | 0.81 |
| "k" | 10.30±0.04 | 0.18 | 0.14 |

The error limits in the above table represent the 95% confidence intervals based on the three measurements. The colour indices of all the stars listed are unremarkable and

present no problem for visual estimation. Note that star "63" listed above is that marked on chart 652 and not "c" on chart 653. The published values of the lettered comparison stars "d", "g", "f" & "k" are all too bright by about 1.1 magnitudes; star "c" on chart 653 is too bright by 2.8 magnitudes. Presumably an error was made in the original determinations, most probably being an incorrect identification of the comparison star or misreading its magnitudes from published sources.

The star V821 Centauri has been classed as a PV Tel type with a probable amplitude of about 0.1 magnitudes. This may make it an unsuitable object for visual estimation.

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(2) Menzies,J.W., Banfield,R.M., Cousins,A.W.J. & Laing,J. 1989. S.Afr.Ast.Obs., Circ., 13,1.

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## VISUAL LIGHT CURVE OF NOVA SGR 1992 No. 2 (V4169 Sgr)

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Henderson, Auckland N.Z.

SUMMARY: The visual light curve of Nova Sgr 1992 No. 2 (V4169 Sgr) is reproduced. It declined 3.08 magnitudes in 38 days followed by an abrupt change in the decline so that it took 80 days to decline a further 2.4 magnitudes.

- - - - - -

### 1. INTRODUCTION

This nova was discovered by W. Liller on July 6, 1992. Visual observations commenced on July 14 using preliminary charts from M. Morel, B. Sumner and T. Richards. These charts were soon replaced by a final chart from Mati Morel. This showed V magnitudes for comparison stars measured by A.C. Gilmore, Mt. John University Observatory. These are shown on charts 1101/2 (1).

## 2. OBSERVATIONS

Figs. 1 and 2 show the light curve from J.D. 2,448,815 to 2,449,300. This is from visual estimates by members of the Variable Star Section, Royal Astronomical Society of New Zealand. There is more scatter in the estimates than desirable but this may reflect real fluctuations in the nova. However, some estimates are obvious errors in identification of either the nova or the comparison stars. These have not been erased from the light curve but were rejected in forming daily means, which agree closely with V observations kindly supplied by A.C. Gilmore.

## 3. DISCUSSION

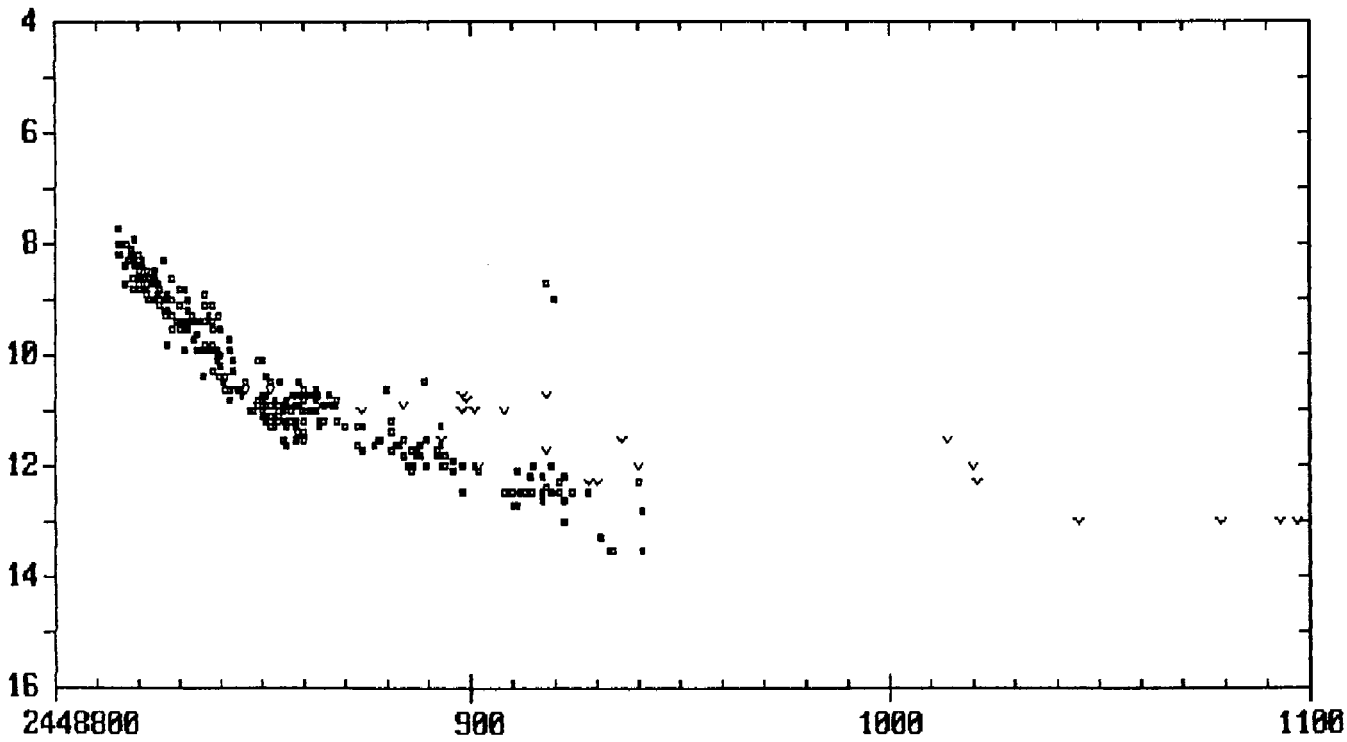
The nova declined 3.08 magnitudes in 38 days at 0.081 mags/day. This was followed by an abrupt change in the rate of decline to 0.03 mags/day taking 80 days to decline a further 2.4 magnitudes.

## ACKNOWLEDGEMENTS

A.C. Gilmore supplied the magnitudes for comparison stars and details of his measures of the nova. Mati Morel was responsible for the final chart, whilst Bruce Sumner and T. Richards distributed preliminary charts. I am indebted to all members for their estimates.

## REFERENCE

(1) Bateson, F.M. & Morel, M. 1992. Charts for Southern Variables, Series 23. Published by Astronomical Research Ltd., Tauranga, New Zealand.




NOVA SGR 1992 No. 2 (V4169 Sgr)

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS
J.D. 2,448,815 - J.D. 2,449,100

# AH ERIDANI - VISUAL OBSERVED OUTBURSTS

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SUMMARY: Visual observations of the dwarf novae AH Eri give an extreme range of 13.2 to 16.6 although minima are probably fainter than 16.6. The mean magnitude at outbursts is 13.66; mean width 4.2 days with a probably short outburst cycle.

. . . . . .

## 1. INTRODUCTION

Observations from J.D. 2,443,509 to 2.444.970 (1977 Dec. 31 to 1981 Dec. 31) were discussed by Bateson (1). AH Eri had been monitored for two decades prior to 1977 Dec. 31 but no outbursts recorded. This was puzzling as the Harvard photographic data (2) indicate a short outburst cycle. Charts 311/2 (3) had been traced from Brun & Petit. It was found that the position of AH Eri was incorrect and a correction was published (4) which was incorporated into Chart 660 (5) which also showed the V sequence by Vogt (6). All observations since 1977 Dec. 31 have been reduced using this sequence. Bateson (7) brought the list of observed outbursts to J.D. 2,445,919.

AH Eri is classified (8) as a dwarf nova of U Gem type with a range of 13.5p to 18.4p. Skody et al (9) found a 42 min rotational period for the white dwarf consistent with a DQ Her pulse adding that it was not possible to rule out periodic amplitude changes in the system vs. colour effects.

## 2. OBSERVATIONS

Table 1 lists the observed outbursts from J.D. 2,445,920 to 2,449,253 (1993 Dec. 31). All observations were made visually by members of the Variable Star Section, Royal Astronomical Society of New Zealand, using the V sequence on Chart 660. Most observations were negative with a scattering of positive estimates in the range of 15.0 to 16.6.

The observing season for AH Eri is August through April with an occasional estimate in July. The observations are scattered in time even in the observing season, because AH Eri has not been as closely monitored as other southern dwarf

novae due to the faintness of its outbursts. This factor has limited observations to those members whose instruments have a threshold of 14.5 or fainter. This means in general that most estimates came from the most experienced observers.

## 3. DISCUSSION

This discussion is based on the observed outbursts shown in Table 1 plus those in the two previous papers (1;7). The mean maximum magnitude is 13.66 with a range of 13.2 to 14.0. The mean width at maximum is 4.2 days ranging from 1 to 14 days for those maxima that were well enough observed to determine this value. However, the widths only represent a very small segment of the light curve, usually that portion brighter than 14.5.

Large gaps in the records make it difficult to be certain that many of the observed outbursts are consecutive. Taking intervals of 100 days, or less, which are definite a mean cycle of 54.4 days is derived, whilst if only intervals of 80 days or less is used the mean cycle becomes 41.7 days. The best that can be stated is that the mean cycle is comparatively short.

## 4. CONCLUSIONS

AH Eri behaves visually as a dwarf novae whose magnitude at maxima varies little from a mean of 13.66 whilst at minima it falls below 16.6. Large gaps in the observations make it impossible to be definite on the mean outburst cycle beyond stating that it is fairly short, possibly around 42 days. There is no evidence to suggest that long and short outbursts alternate or that long outbursts are associated with a brighter maximum magnitude. The mean width at maxima is 4.2 days but this only refers to the top segment of the light curve from maximum to 14.5.

Observers with instruments having thresholds of 14.5 and fainter are urged to pay more attention to AH Eri, especially to follow it closely throughout any outburst.

## ACKNOWLEDGEMENTS.

All observers are thanked for their observations.

## TABLE 1

## AH ERIDANI - OBSERVED OUTBURSTS

| No. | J.D. Max 24 ..... | Max Mag v | Int d | Width d | Remarks |
|---|---|---|---|---|---|
| 21 | 46,059 | 13.7 | (612) | 8 | ) |
| 22 | 46,067 | 13.8 | ? | | )Same outburst? |
| 23 | 46,460 | 13.8 | (393) | 2? | |
| 24 | 46,757 | 13.7 | (297) | 2? | |
| 25 | 46,815 | 13.7 | 58 | 4 | |
| 26 | 46,878 | 13.8 | 63 | 7 | |
| 27 | 47,126 | 13.8 | (248) | 3? | |
| 28 | 47,214 | 13.8 | 88 | 4 | |
| 29 | 47,580 | 13.6 | (366) | 1+ | Fall not seen |
| 30 | 47,770? | 13.8 | (190?) | A single observation | |
| 31 | 47,863? | 14.0? | 93? | Poss. fading from | |
| 32 | 47,964 | 13.8 | 101 | 9 | |
| 33 | 48,214 | 13.8 | (250) | 10 | |
| 34 | 48,618? | 13.9 | (404?) | Single observation | |
| 35 | 48,650 | 13.8 | 32? | 6+ | |
| 36 | 48,814 | 13.7 | (164) | 4+ | |
| 37 | 48,980 | 13.8 | (166) | 4 | |
| 38 | 49,035 | 13.7 | 55 | 4 | |
| 39 | 49,327 | 13.9 | (292) | 3 | |

NOTES TO TABLE 1

? = Some uncertainty of figure quoted.
+ = Width greater than stated as either start or end of outburst not seen.

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# RR and AO OCTANTIS - PHOTOMETRY OF COMPARISON STARS

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SUMMARY: Photometry of the comparison stars around RR and AO Octantis is reported.

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## 1. INTRODUCTION

RR and AO Octantis are shown on charts 1029 and 1030 (1).

RR Octantis (R.A. = 20h 55m 44s, Dec = 74° 58′.6", (2000) is a Mira variable of magnitude range 10 to fainter than 13.5 over a period of 273 days. Comparison stars "o" to "u" are nearby on the chart with brighter "m" and "n" more distant.

AO Octantis (R.A. = 21h 05m 02s, Dec = 75° 21′.5", (2000) is a U Geminorum type with a photographic magnitude range of 13.5 to 21. Comparison stars "a" to "h" are nearby.

## 2. OBSERVATIONS

The observations were made on 1992 September 29 in excellent sky conditions with Mt. John's photometer No. 1 on the 0.6m Boller & Chivens Cassegrain reflector. A cooled EMI 9558B (S-20) photomultiplier tube was used with pulse counting electronics.

The comparison stars were measured differentially from HR 8111 located 90′ ESE of RR Oct and 50′ E of AO Oct and marked as "66" on chart 1029. A check was provided by HR 8052, also "66", SSE of the variables. The assumed brightness and colour of these stars was obtained from the Bright Star Catalogue (3) which gives the following co-ordinates and photometry:

| | | R.A. (2000) | Dec. | V | B-V | U-B |
|---|---|---|---|---|---|---|
| | | h m s | ° ′ " | | | |
| Reference star .. .. | HR 8111 | 21 18 16 | -75 20 49 | 6.63 | +0.03 | +0.00 |
| Check star | HR 8052 | 21 08 48 | -76 12 46 | 6.58 | +1.23 | +1.18 |

HR 8111 was observed before and after each comparison star, with three integrations of 5 seconds in U and 1 second in B and V. Comparison stars were measured with integration times ranging up to 100 seconds. Each comparison star was observed twice with a sky reading of the same integration time between. The check star was observed three times through the session showing mean residuals (observed -

B.S. Cat.) and standard deviations of +0.01 +/- 0.01, +0.03 +/- 0.00, and +0.06 +/- 0.03 in V, B-V and U-B respectively. Observations were made over an air mass range of 1.27 - 1.67.

RR Oct's comparison star "y" was too close to the bright variable for accurate measurement.

The data was reduced using the Mt. John software (2) and extinction co-efficients derived for night. The results with the standard deviations of the measures and mean air mass are listed in Tables 1 and 2. The standard deviation columns are headed with sV, s(B-V) and s(U-B). Stars are listed in order of V magnitude for each variable.

ACKNOWLEDGEMENTS
Pam Kilmartin provided reductions of the mean extinction co-efficients.

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TABLE 1
RR OCTANTIS - COMPARISON STARS

| Star | V | B-V | U-B | sV | s(B-V) | s(U-B) |
|---|---|---|---|---|---|---|
| m | 8.37 | +0.28 | +0.04 | 0.00 | 0.00 | 0.00 |
| n | 9.67 | +0.43 | -0.05 | 0.01 | 0.00 | 0.00 |
| o | 9.97 | +1.12 | +1.07 | 0.01 | 0.01 | 0.03 |
| p | 10.48 | +0.50 | - | 0.00 | 0.00 | - |
| q | 10.76 | +0.89 | - | 0.02 | 0.01 | - |
| r | 11.01 | +0.37 | - | 0.01 | 0.00 | - |
| s | 12.16 | +0.67 | - | 0.01 | 0.01 | - |
| t | 12.40 | +0.63 | - | 0.01 | 0.01 | - |
| u | 13.17 | +1.16 | - | 0.01 | 0.00 | - |
| w | 13.20 | +1.03 | - | 0.04 | 0.07 | - |
| v | 13.23 | +1.09 | - | 0.03 | 0.04 | - |
| x | 13.88 | +0.95 | - | 0.03 | 0.02 | - |

TABLE No. 2
AO OCTANTIS - COMPARISON STARS

| Star | V | B-V | sV | s(B-V) |
|---|---|---|---|---|
| b | 9.97 | +1.18 | 0.00 | 0.00 |
| a | 10.87 | +0.53 | 0.00 | 0.01 |
| c | 11.14 | +1.41 | 0.00 | 0.00 |
| d | 12.09 | +0.59 | 0.00 | 0.01 |
| f | 13.52 | +0.81 | 0.04 | 0.03 |
| e | 13.58 | +1.24 | 0.03 | 0.02 |
| g | 13.91 | +0.45 | 0.03 | 0.02 |
| h | 14.05 | +0.74 | 0.03 | 0.01 |

# THE MIRA VARIABLE - T COLUMBAE

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SUMMARY: Observed dates of maxima and minima derived from several decades of visual observations are listed. The light curve is reproduced with O-C plots, which appear to show a decrease in the period by almost two days.

## 1. INTRODUCTION:

Leon Campbell (1) discussed the Harvard photographic observations (1899 to 1905) and visual data (1918 to 1926). He gave two O-C diagrams. The first from a linear formula gave a mean period of $225^d.0$, but indicated a definite change in period. His second O-C curve used the same formula with the addition of a secular term. This showed the usual slight variations on either side of the mean period and no marked deviation therefrom.

The current period of T Col is $225^d.85$ (2).

T Col is most suitable for monitoring with small telescopes as its entire range is within their thresholds.

## 2. OBSERVATIONS:

Visual observations by members of the Variable Star Section, RASNZ, cover the years 1932 to 1993. The observing season is August through May. A limited number of estimates were made in July. The coverage was uneven, being sparse in the first few years when there were few observers. T Col was then well observed for many years, but estimates fell off towards the end of the interval reviewed when the attention of observers was diverted to special programmes.

Observations from 1932 were made using a photographic chart supplied by Harlow Shapley with the Harvard sequence shown thereon. Copies of this chart were used until the publication of charts 152/3 (3) which showed the Harvard sequence. V magnitudes for the comparison stars were measured at the Auckland observatory by B.Menzies (4). Following publication of these magnitudes in 1977, all estimates were reduced using the V sequence.

## 4. DISCUSSION:

Portions of the light curve are included at the end of this paper. Observed dates of maxima and minima are listed in Tables 1 & 2.

The O-C values in Table 1 were derived from the following linear formula:

**J.D. Max 2,441,742 E $\pm$ $226.^d91$ M-m 113 days**

Those in table 2 were represented by:

**J.D. Max 2,448,031 E $\pm$ $224^d.24$ M-m 113 days**

The respective O-C curves are shown in Figs. 1 - 2.

The differences in the above formulae implies that there has been a decrease in the period of 1.9 days. This apparent decrease may not be real, but merely a result of less intense coverage of T Col in recent years.

The range of maxima was 6.5 to 8.3 and minima from 10.8 to 12.8. The respective mean values are:

MAXIMUM: 7.5 MINIMUM: 11.9

5. SUMMARY:

There is an apparent decrease in the period of T Col from 226.91 to 224.24 days. This should be viewed with caution owing to the changing frequency of the observations between one interval and the other.

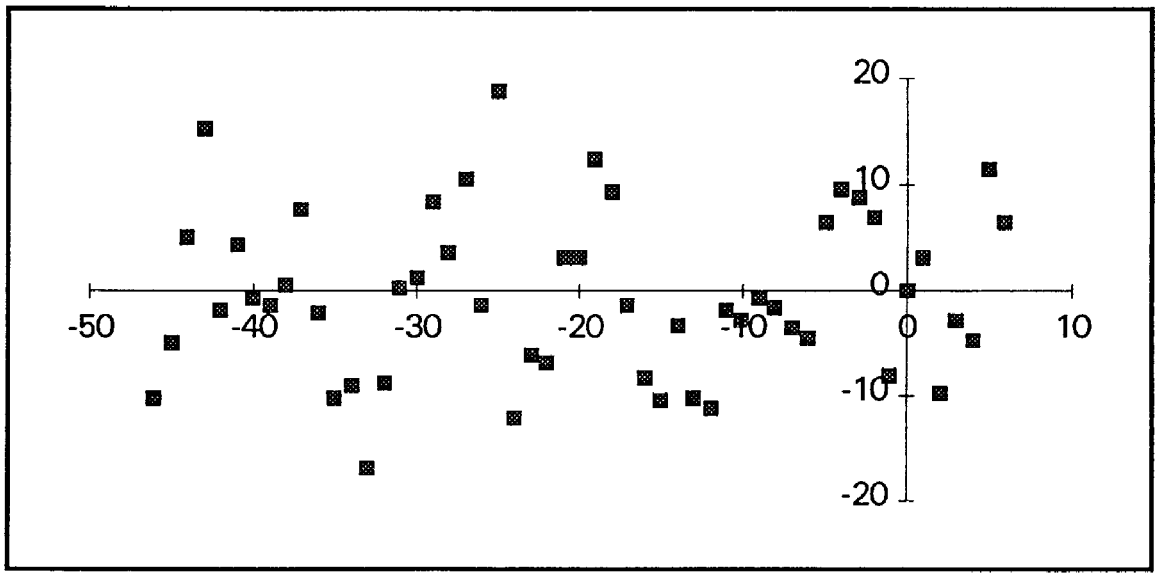


**Fig 1:** T Col O-C diagram for JD 2431294 to 2443110

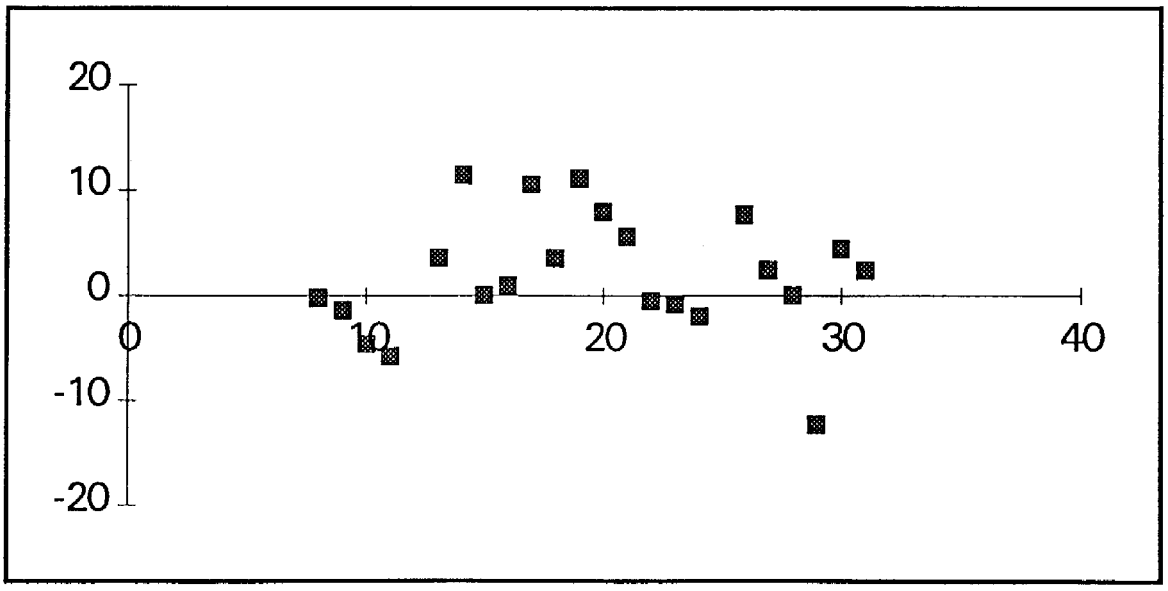


**Fig 2:** T Col O-C diagram for JD 244354 to 2448706

| No. | $Mag_v$ | JD Max 24 ..... | O - $C_d$ | $Mag_v$ | JD Min 24..... | O - $C_d$ |
|---|---|---|---|---|---|---|
| -46 | 7.3 | 31294 | -10 | 12.1 | 31410 | - 8 |
| -45 | 7.3 | 526 | - 5 | 12.5 | 643 | - 2 |
| -44 | 8.1 | 763 | + 5 | 12.0 | 857 | -14 |
| -43 | 7.0 | 32000 | +15 | 11.8 | 32085 | -13 |
| -42 | 7.6 | 210 | - 2 | 12.2 | 326 | + 1 |
| -41 | 7.6 | 443 | + 4 | 12.3 | 547 | - 5 |
| -40 | 7.4 | 665 | - 1 | 11.8 | 775 | - 4 |
| -39 | 8.3 | 891 | - 2 | 12.1 | 995 | -11 |
| -38 | 7.8 | 33120 | + 1 | 11.8 | 33224 | - 9 |
| -37 | 7.4 | 354 | + 8 | 11.5 | 455 | - 5 |
| -36 | 7.2 | 571 | - 2 | 11.5 | 686 | - 1 |
| -35 | 7.4 | 790 | -10 | 11.3 | 910 | - 4 |
| -34 | 7.3 | 34018 | - 9 | 11.9 | 34148 | + 7 |
| -33 | 7.3 | 237 | -17 | 12.1 | 360 | - 7 |
| -32 | 7.3 | 472 | - 9 | 11.9 | 594 | 0 |
| -31 | 7.3 | 708 | +-0 | 12.1 | 814 | - 7 |
| -30 | 6.9 | 936 | + 1 | 11.7 | 35042 | - 6 |
| -29 | 7.9 | 35170 | + 8 | 12.2 | 276 | + 1 |
| -28 | 7.1 | 392 | + 3 | 11.9 | 495 | - 7 |
| -27 | 7.5 | 626 | +11 | 12.2 | 736 | - 7 |
| -26 | 7.5 | 841 | - 1 | 12.2 | 965 | + 9 |
| -25 | 8.2 | 36088 | +19 | 11.9 | 36200 | +17 |
| -24 | 7.5 | 284 | -12 | 11.2 | 425 | +15 |
| -23 | 6.5 | 517 | - 6 | 11.9 | 639 | + 2 |
| -22 | 7.5 | 743 | - 7 | 11.9 | 859 | - 4 |
| -21 | 7.5 | 980 | + 3 | 12.5 | 37099 | + 9 |
| -20 | 7.8 | 37207 | + 3 | 12.8 | 328 | +11 |
| -19 | 8.3 | 443 | +12 | 12.0 | 550 | + 6 |
| -18 | 7.2 | 667 | + 9 | 12.0 | 780 | + 9 |
| -17 | 7.3 | 883 | - 2 | 11.9 | 38008 | +10 |
| -16 | 6.8 | 38103 | - 8 | 11.5 | 226 | + 1 |
| -15 | 7.3 | 328 | -10 | 11.9 | 451 | - 1 |
| -14 | 7.8 | 562 | - 3 | 12.3 | 674 | - 5 |
| -13 | 7.0 | 782 | -10 | 12.3 | 894 | -12 |
| -12 | 6.9 | 39008 | -11 | 12.6 | 39138 | + 5 |
| -11 | 7.4 | 244 | - 2 | 12.7 | 349 | -10 |
| -10 | 6.8 | 470 | - 3 | 12.2 | 584 | - 2 |
| - 9 | 7.0 | 699 | - 1 | 12.7 | 827 | +14 |
| - 8 | 7.8 | 925 | - 2 | 11.8 | 40067 | +27 |
| - 7 | 6.7 | 40150 | - 4 | 11.3 | 287 | +20 |
| - 6 | 7.3 | 376 | - 5 | 11.2 | 505 | +11 |
| - 5 | 7.4 | 614 | + 7 | 12.3 | 725 | + 4 |
| - 4 | 7.4 | 844 | +10 | 12.3 | 40948 | 0 |
| - 3 | 7.3 | 41070 | + 9 | 12.3 | 184 | + 9 |
| - 2 | 7.2 | 295 | + 7 | 12.2 | 413 | +11 |
| - 1 | 6.9 | 507 | - 8 | 11.9 | 652 | +23 |
| 0 | 7.1 | 742 | +-0 | 11.4 | 866 | +11 |
| + 1 | 7.1 | 972 | + 3 | 11.5 | 42090 | + 8 |
| + 2 | 6.9 | 42186 | -10 | 12.0 | 314 | + 5 |
| + 3 | 7.7 | 420 | - 3 | 12.3 | 531 | - 5 |
| + 4 | 7.8 | 645 | - 5 | 12.4 | 757 | - 6 |
| + 5 | 7.3 | 888 | +11 | 12.2 | 992 | + 2 |
| + 6 | 7.8 | 43110 | + 7 | 12.5 | 43210 | - 7 |
| + 7 | ? | ? | ? | 11.5 | 434 | -10 |

**Table 1:** Observed Maxima & Minima of T Columbae

| No. | $Mag_v$ | JD Max 24 ..... | O - $C_d$ | $Mag_v$ | JD Min 24..... | O - $C_d$ |
|---|---|---|---|---|---|---|
| + 8 | 7.1 | 4354 | +-0 | 11.9 | 43659 | + 1 |
| + 9 | 7.5 | 769 | - 1 | 11.8 | 882 | - 1 |
| +10 | 6.8 | 990 | - 5 | 11.8 | 44097 | -10 |
| +11 | 7.1 | 44213 | - 6 | 12.4 | ? | ? |
| +12 | 7.9 | ? | ? | 12.5 | 557 | + 2 |
| +13 | 7.0 | 671 | + 4 | 12.3 | 780 | +-0 |
| +14 | 7.8 | 903 | +11 | 11.1 | 45027 | +23 |
| +15 | 7.0 | 45116 | +-0 | 11.3 | 253 | +25 |
| +16 | 7.3 | 341 | + 1 | 10.8 | 456 | + 4 |
| +17 | 7.8 | 575 | +11 | 12.2 | 680 | + 4 |
| +18 | 8.0 | 792 | + 3 | 11.3 | 916 | +15 |
| +19 | 7.7 | 46024 | +11 | 11.7 | 46141 | +16 |
| +20 | 8.0 | 245 | + 8 | 12.0 | 367 | +18 |
| +21 | 8.0 | 467 | + 6 | 12.0 | 578 | + 5 |
| +22 | 7.8 | 685 | - 1 | 11.4 | 809 | +11 |
| +23 | 7.5 | 909 | - 1 | 11.3 | 47031 | + 9 |
| +24 | 7.5 | 47132 | - 2 | 11.6 | 259 | +13 |
| +25 | ? | ? | ? | 12.2 | 470 | +-0 |
| +26 | 7.3 | 590 | + 7 | 12.5 | 697 | + 2 |
| +27 | 7.5 | 809 | + 2 | 11.8 | 932 | +13 |
| +28 | 6.6 | 48031 | +-0 | 11.8 | 48165 | +22 |
| +29 | 7.7 | 243 | -12 | 11.8 | 392 | +25 |
| +30 | 7.5 | 484 | + 5 | 11.5 | 608 | +16 |
| +31 | 7.6 | 706 | + 2 | ? | ? | ? |

**Table 2:** Observed Maxima & Minima for T Columbae

ACKNOWLEDGMENTS:
Frank Bateson has provided valuable guidance in enabling me to compile this paper. I am also indebted to all observers for their estimates and urge them to pay closer attention to T Col.

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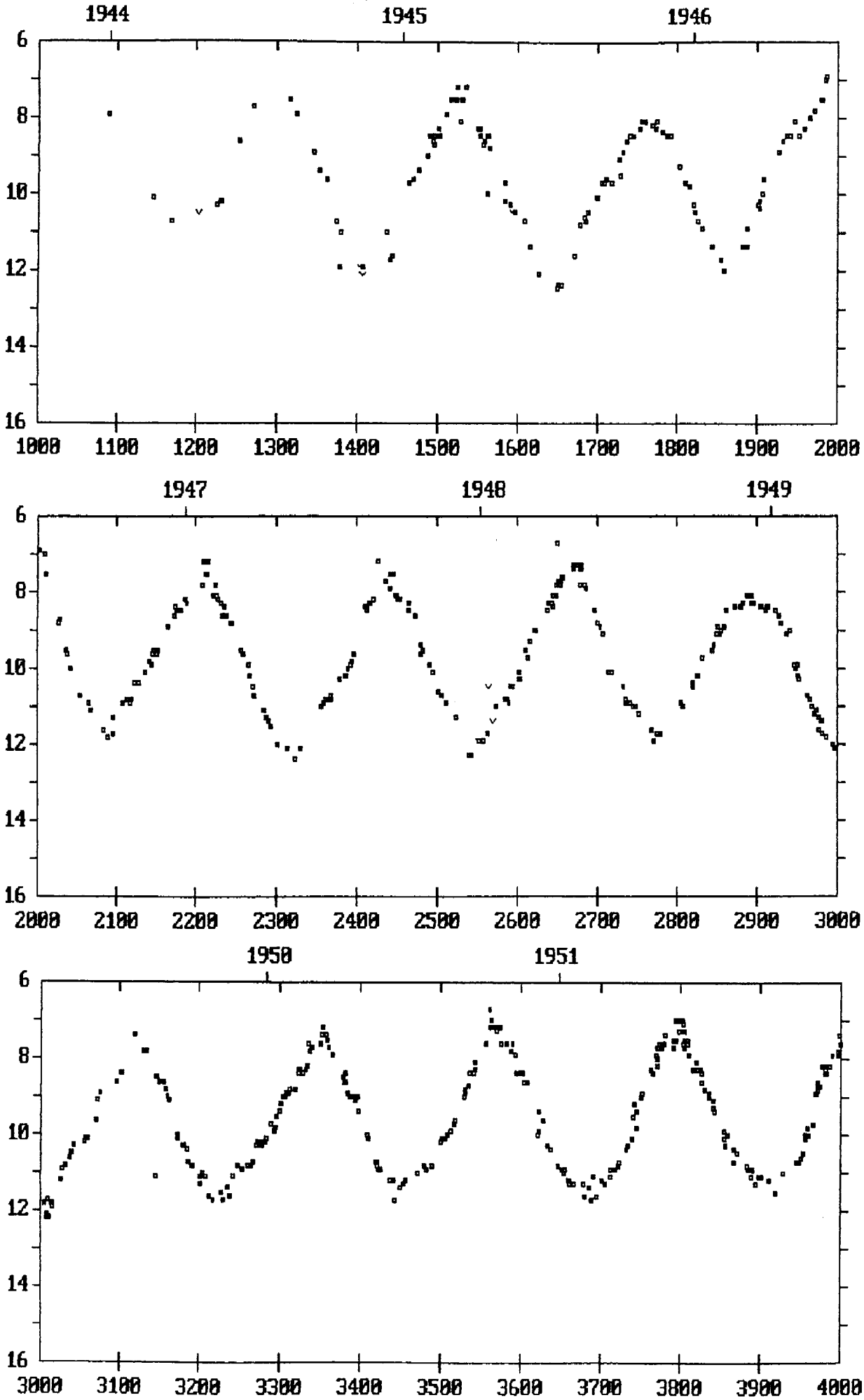


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FIGURE 1

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS
J.D. 2,431,100 - J.D. 2,434,000

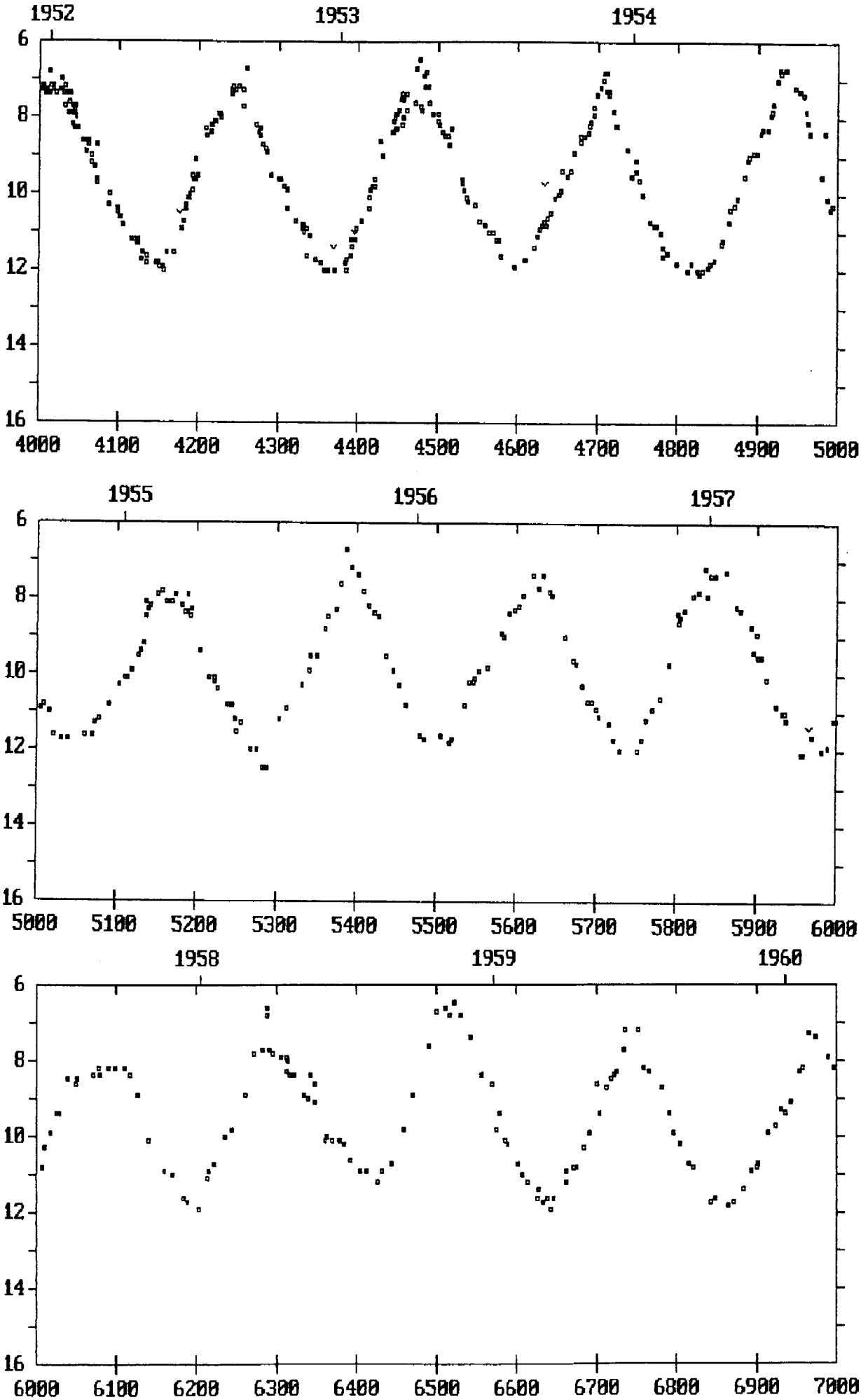


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FIGURE 2
LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS
J.D. 2,434,000 - J.D. 2,437,000

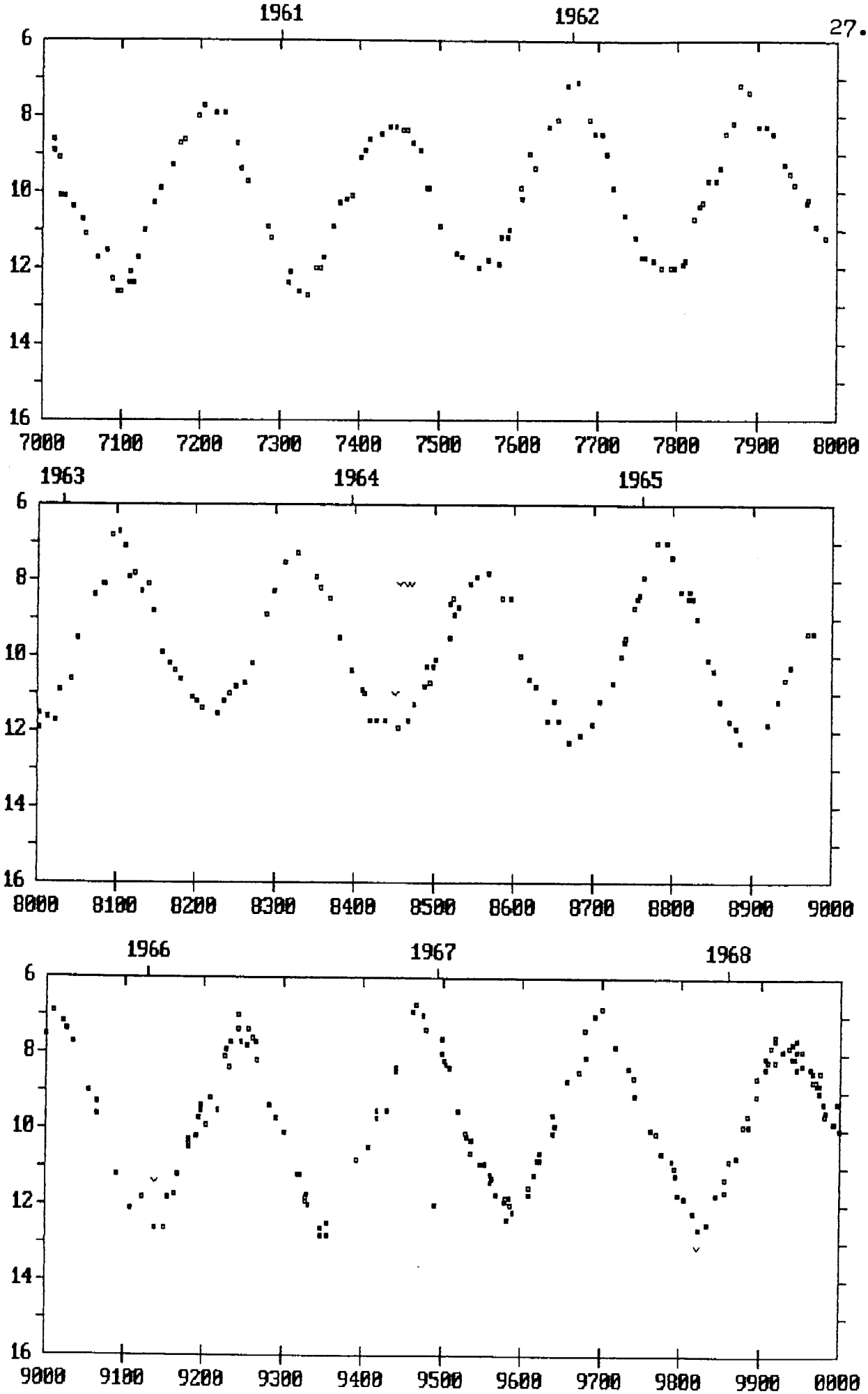


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FIGURE 3
LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS
J.D. 2,437,000 - J.D. 2,440,000

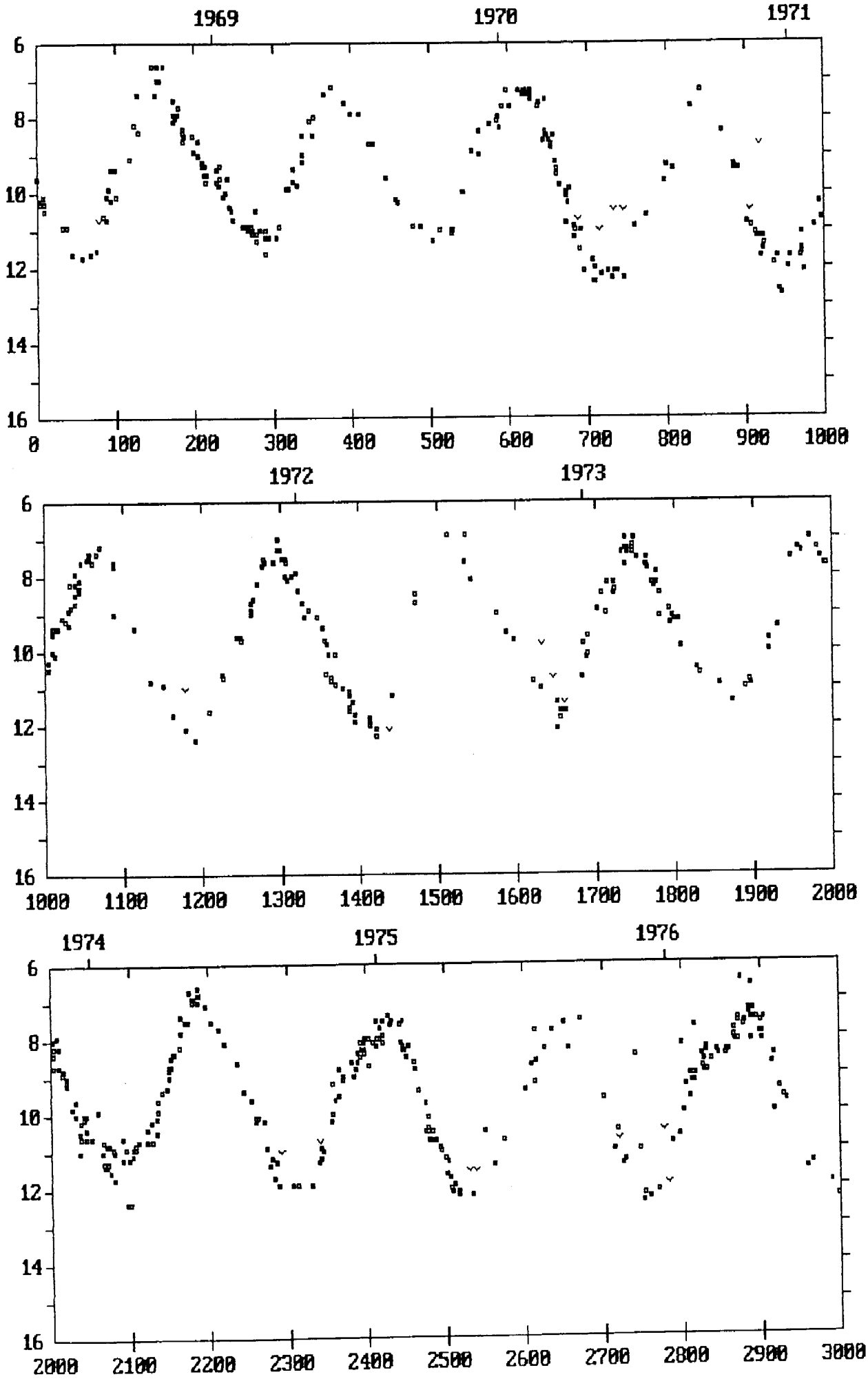


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FIGURE 4
LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS
J.D. 2,440,000 - J.D. 2,443,000

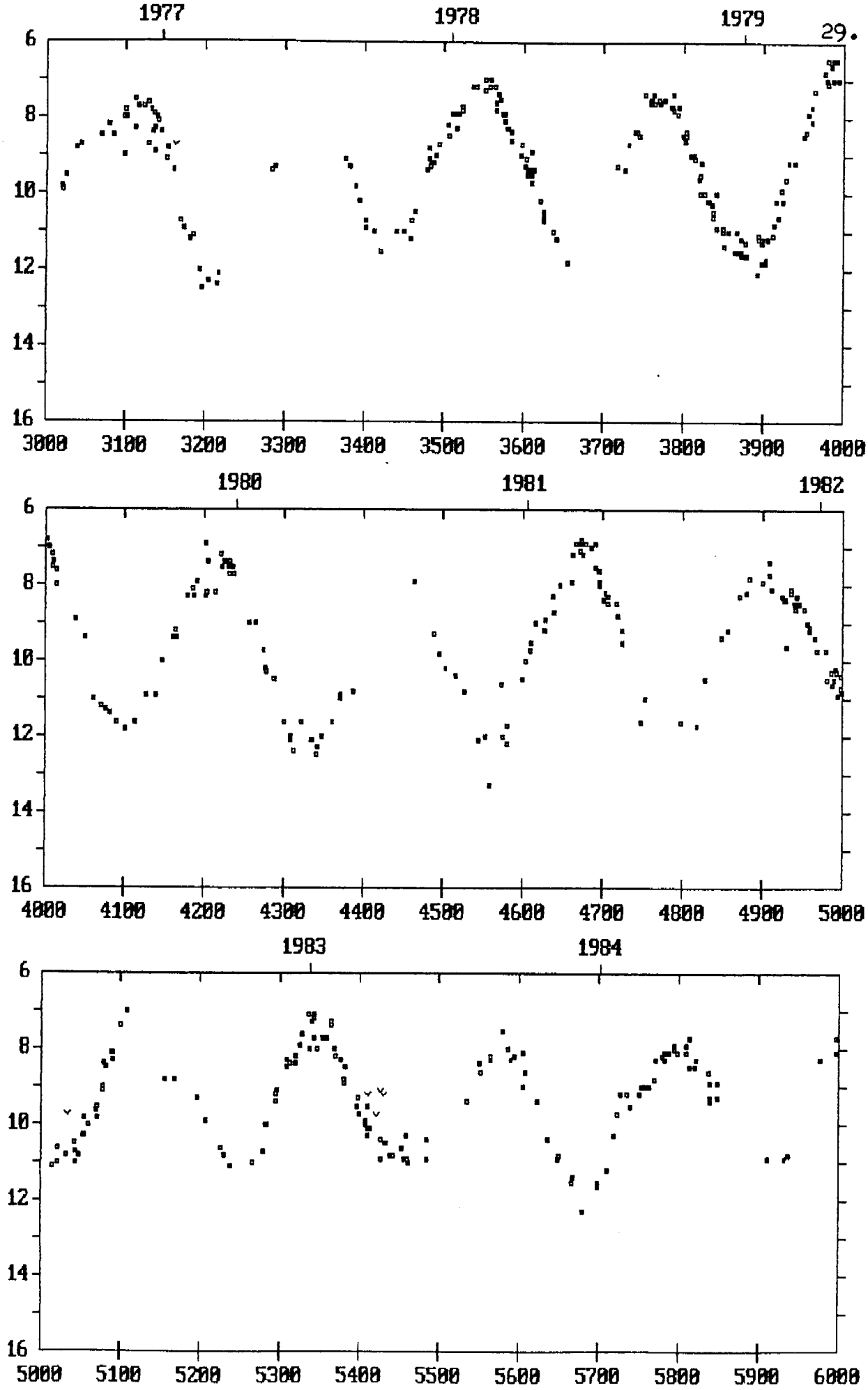


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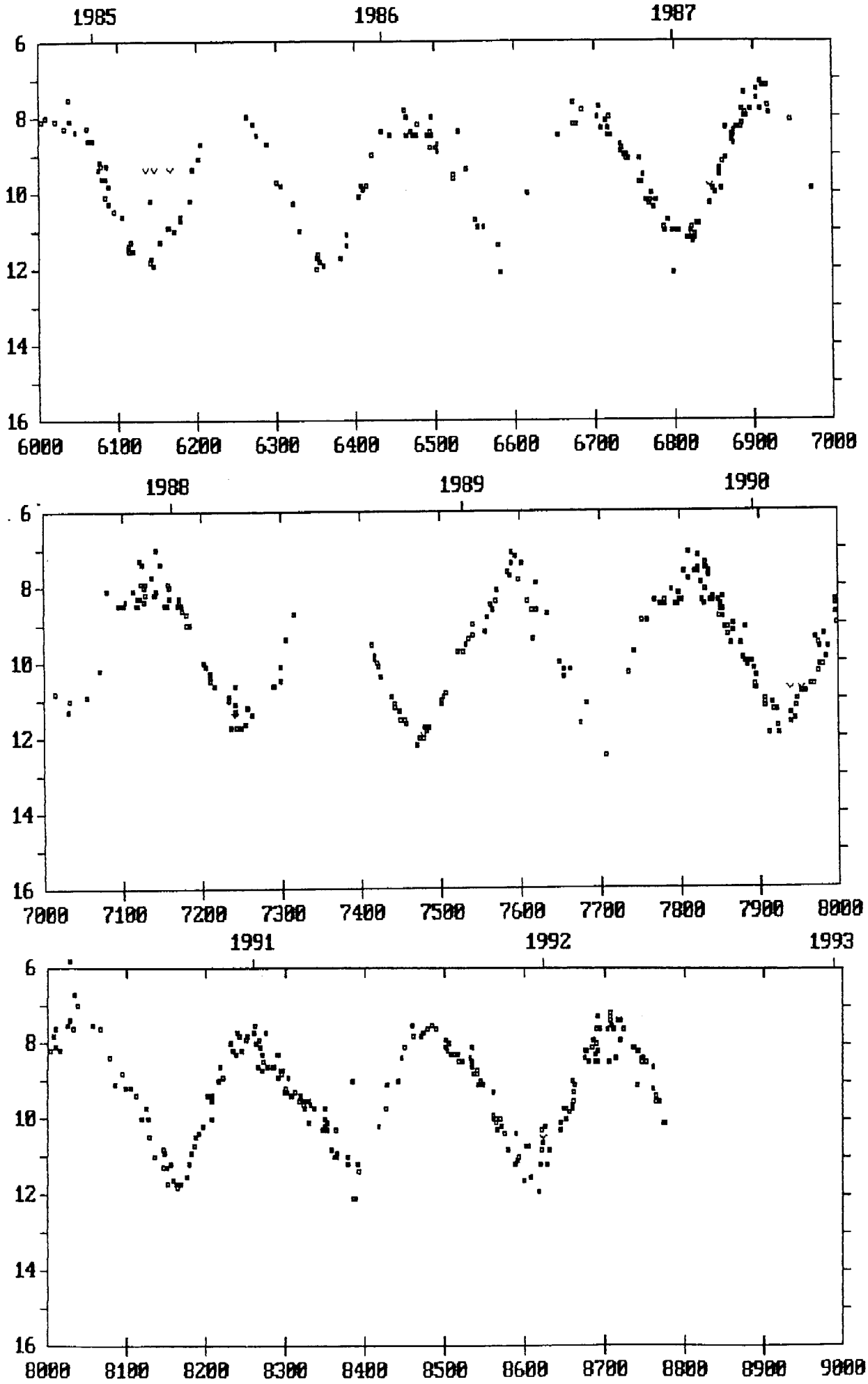
FIGURE 5
LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS
J.D. 2,443,000 - J.D. 2,446,000




T COL

FIGURE 6
LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS
J.D. 2,446,000 - J.D. 2,448,775

# THE VISUAL LIGHT CURVE OF THE SYMBOTIC VARIABLE SY MUSCAE

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SUMMARY: The light curve of SY Mus covers the interval June 21, 1954 to 29 May, 1993. No outburst was recorded. SY Mus had a small irregular variation. A separate investigation found a period of 624.5 days for the eclipses.

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## 1. INTRODUCTION

SY Mus is a symbotic variable, type Z And. Stars of this type are classified as a sub-type of C.Vs. They are close binaries consisting of a hot star and a star of late spectral type. An extended envelope is excited by radiation from the hot star. Some Z And stars have outbursts of up to about four magnitudes at irregular intervals.

## 2. OBSERVATIONS

The observations discussed here run from J.D. 2,434,915 (1954, June 21) to 2.449,137 (1993, May 29).

SY Mus is shown on chart 298 (1) with comparison stars denoted by letters. The V and B-V magnitudes for these were determined by B. Menzies, Auckland Observatory and published in a paper by Bateson, Jones and Menzies (2). All estimates have been reduced to the V sequence. That paper also discussed the results from J.D. 2,434,910 to 2,441,510. This gave the following elements:

Min. I J.D. 2,436,460 ± 621.8 days E.
Mean Range 10.8 - 11.8
(Extremes 10.2 - 12.7)

Min. II (mean mag 11.25) tend to occur 170 days before Min. I.

Maxima were found to be broad and flat.
Min. II short and sharp.

Pereira, Vogel & Nussbaumer recently published a paper on the far UV variability of SY Mus (3). They were supplied with our light curve and details of the visual data from which they derived a period for the primary minimum of 624.5 days.

## 3. DISCUSSION

The observations before J.D. 2,440,930 were mainly made by A.F. Jones supplemented by a limited number from Bateson. There were many gaps in the records during this time. Therafter the number of observers and estimates increased as shown by the light curve.

We formed ten day means and found that the means formed from four or more estimates had mean variation from 10.55 to 11.60. This small range coupled with an apparent irregular variation around magnitude 11.0 show that the eclipses of SY Mus should be measured photoelectrically. Strictly speaking we should apply to each visual estimate a correction for each observer's systematic deviation. We concluded that this laborious task was not justified.

Table 1 lists the dates and magnitudes of what we consider to be those of primary minima. These are based on giving due consideration to the reliability of each estimate. Other investigators would undoubtedly tabulate dates differing from those in Table 2 but we consider that those listed are as accurate as the data permits.

The first eleven dates in Table 1 are taken from the previous paper (2) which gave a period of 621.8 days for primary minimum. The period from Table 2 is 624.2 days. No satisfactory date for the epoch could be derived as for each we were left with large O-C residuals. This merely reflects the fact that visual observations are not accurate enough for a variable with such a small mean range.

Maxima are broad and flat. The decline to primary minima appears to be gradual with possibly an abrupt fall at the end of this decline followed by a slow rise. There are indications of a secondary minimum but it is difficult to be certain of this.

The light curve is shown in Figs 1. - 5.

## 4. CONCLUSION

SY Muscae appears to be a stable binary system that has shown no outbursts between 1954 and 1993. Visual observations are useful through long term monitoring in showing no change of a substantial nature has occurred. However, such estimates are not accurate enough to provide precise data on eclipses. A period of 624.2 days seems probable. This star requires photoelectrical measures to provide a precise period and epoch.

ACKNOWLEDGEMENTS

Ranald McIntosh has produced the light curve and print-outs of the observations, whilst the senior author is responsible for the reductions. Observations have been contributed by all members of the Variable Star Section. Special thanks are due to A.F. Jones and M.D. Overbeek for their continuous estimates over decades.

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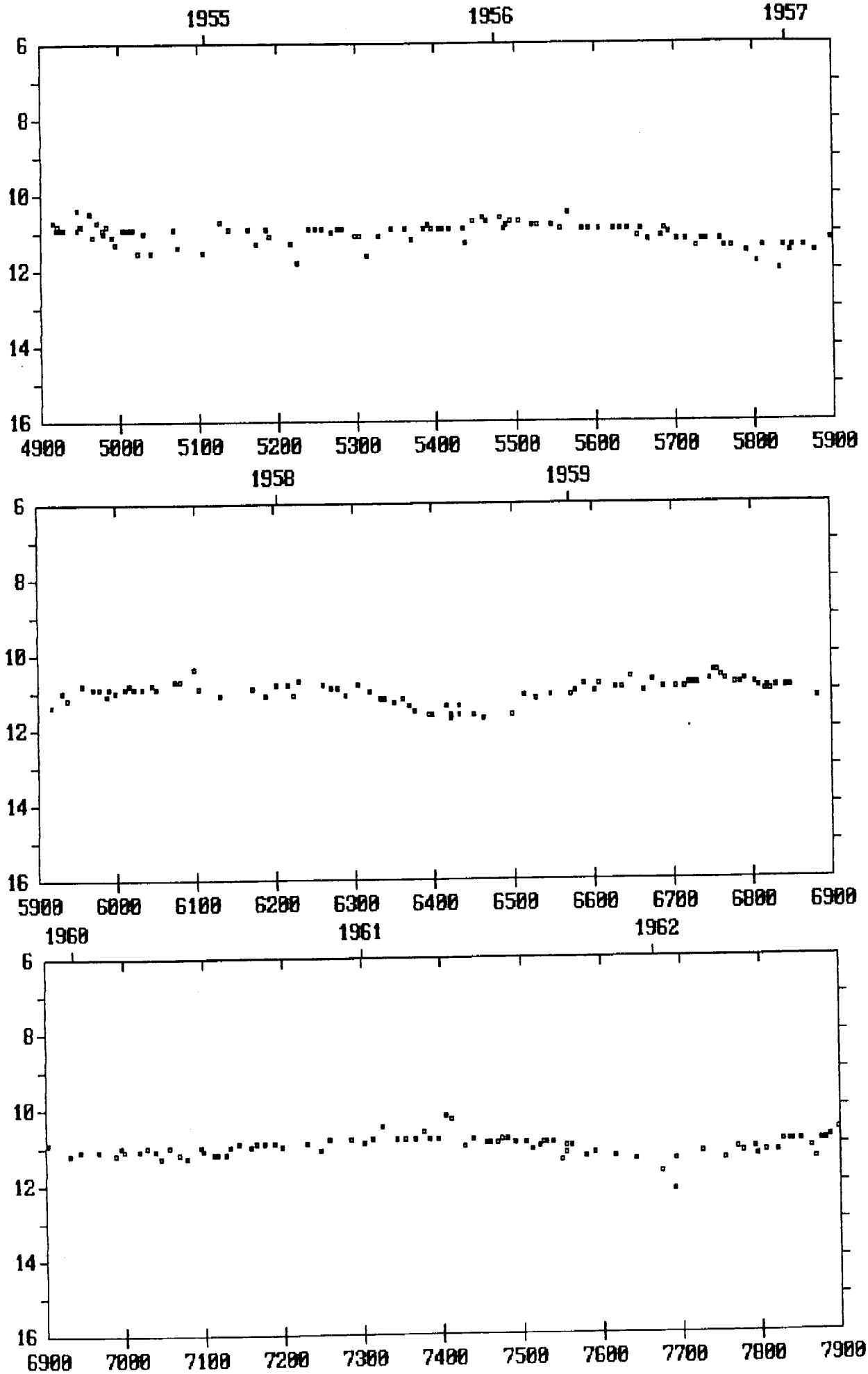
TABLE 1

SY MUSCAE - PRIMARY MINIMUM

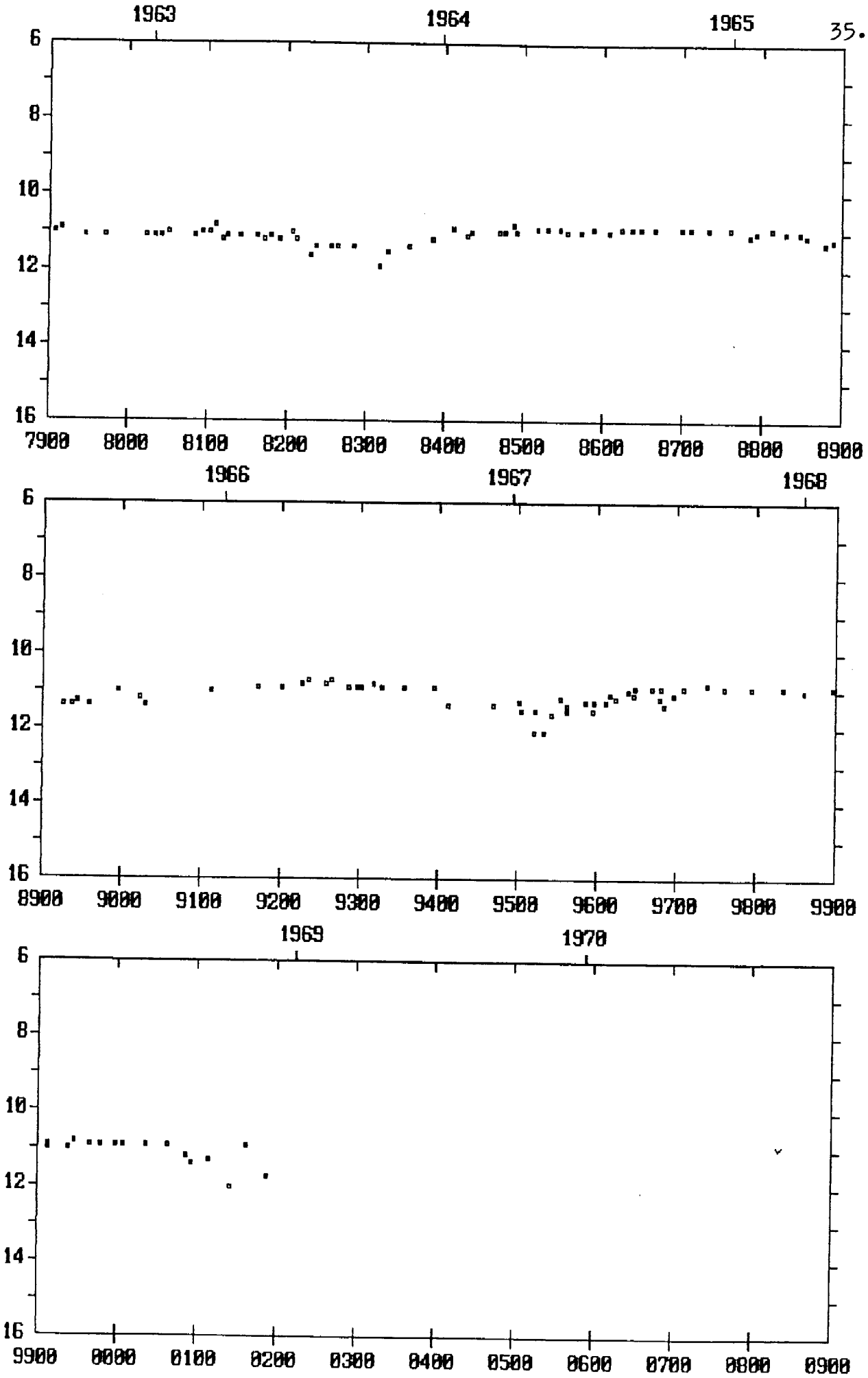
| J.D. 24 ..... | Mag v | Int. d |
|---|---|---|
| 35,222 | 11.5 | - |
| 830 | 11.8 | 608 |
| 36,460 | 11.6 | 630 |
| 37,115 | 11.2 | 655 |
| 710 | 11.8 | 595 |
| 38,318 | 11.9 | 608 |
| 920? | 11.6 | 602 |
| 39,533 | 12.1 | 613 |
| 40,140 | 11.8 | 607 |
| 790? | 11.6? | 650 |
| 41,440? | 12.7? | 650 |
| 42,129 | 12.0 | 689 |
| 42,778 | 11.7 | 649 |
| 43,335 | 12.0 | 557 |
| 997 | 11.3 | 662 |
| 44,648 | 12.3 | 651 |
| 45,180 | 11.5 | 532 |
| 794 | 11.5 | 614 |
| 46,447 | 12.0 | 653 |
| 47,083 | 11.3 | 636 |
| 729 | 11.5 | 646 |
| 48,334 | 11.6 | 605 |
| 945 | 11.7 | 611 |

- - - - - - - - - -



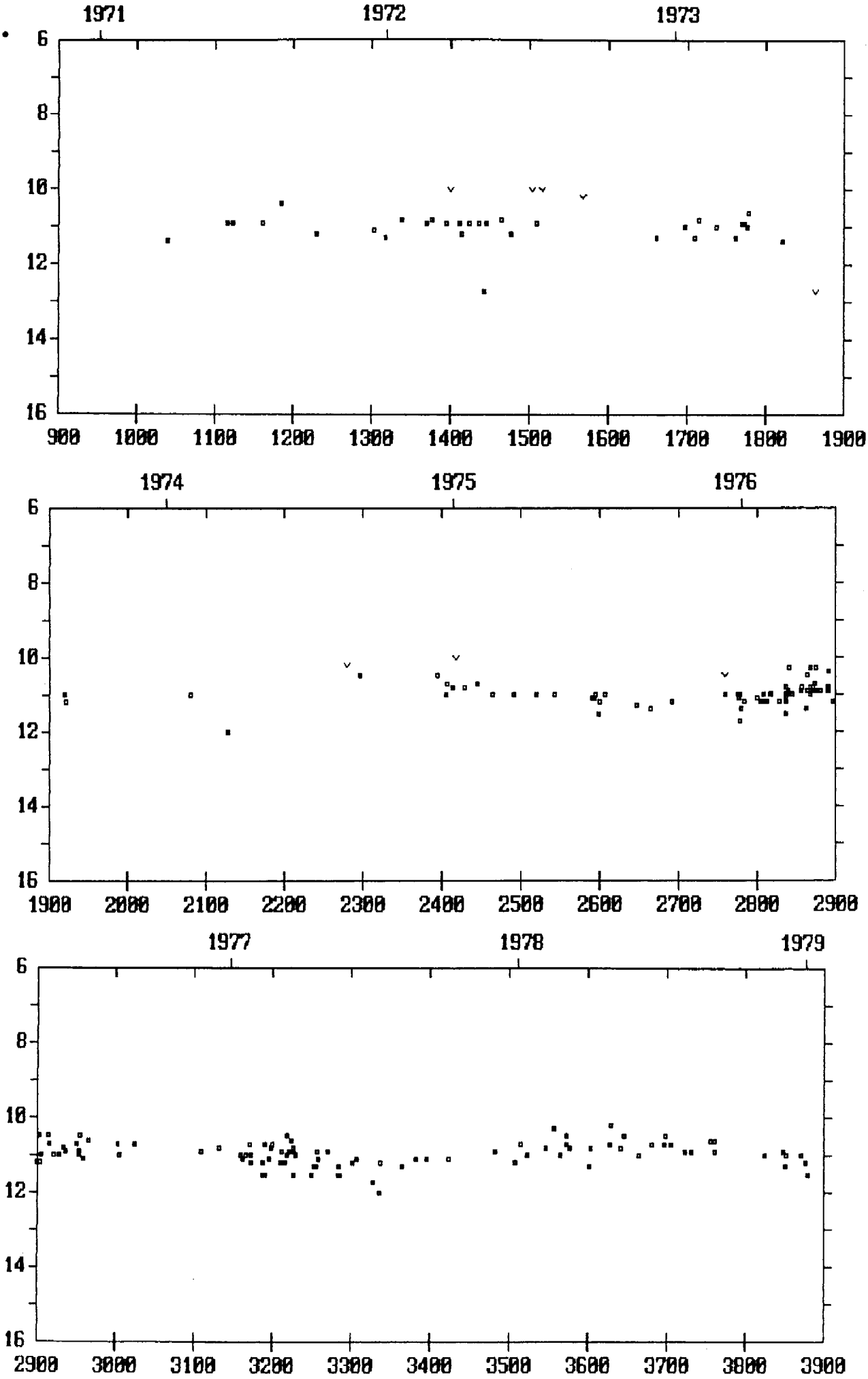

SY MUSCAE

FIGURE 1
Light curve from Individual Observations
J.D. 2,434,915 - J.D. 2,437,900



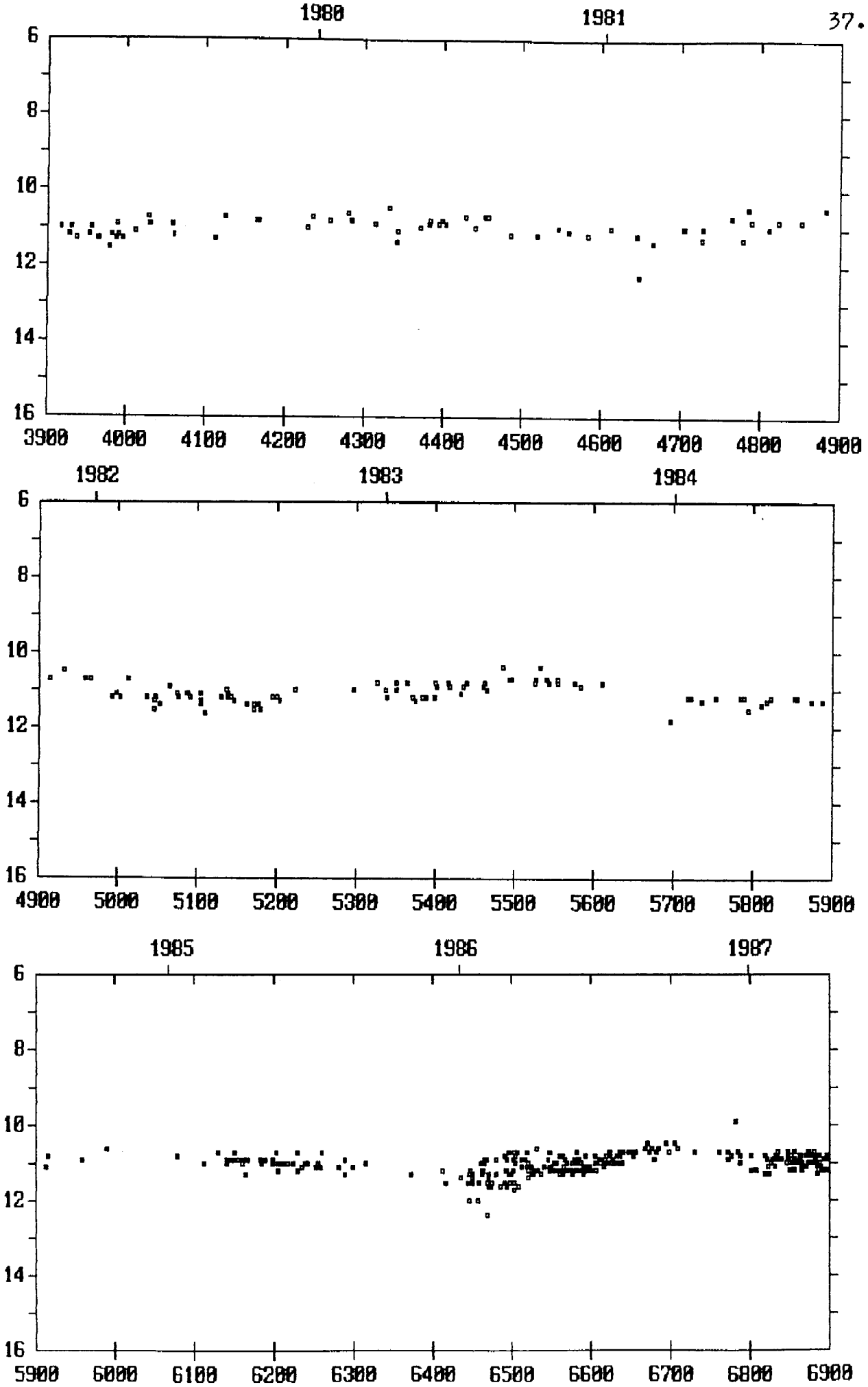

SY MUSCAE

FIGURE 2
Light Curve from Individual Observations
J.D. 2,437,900 - J.D. 2,440,900



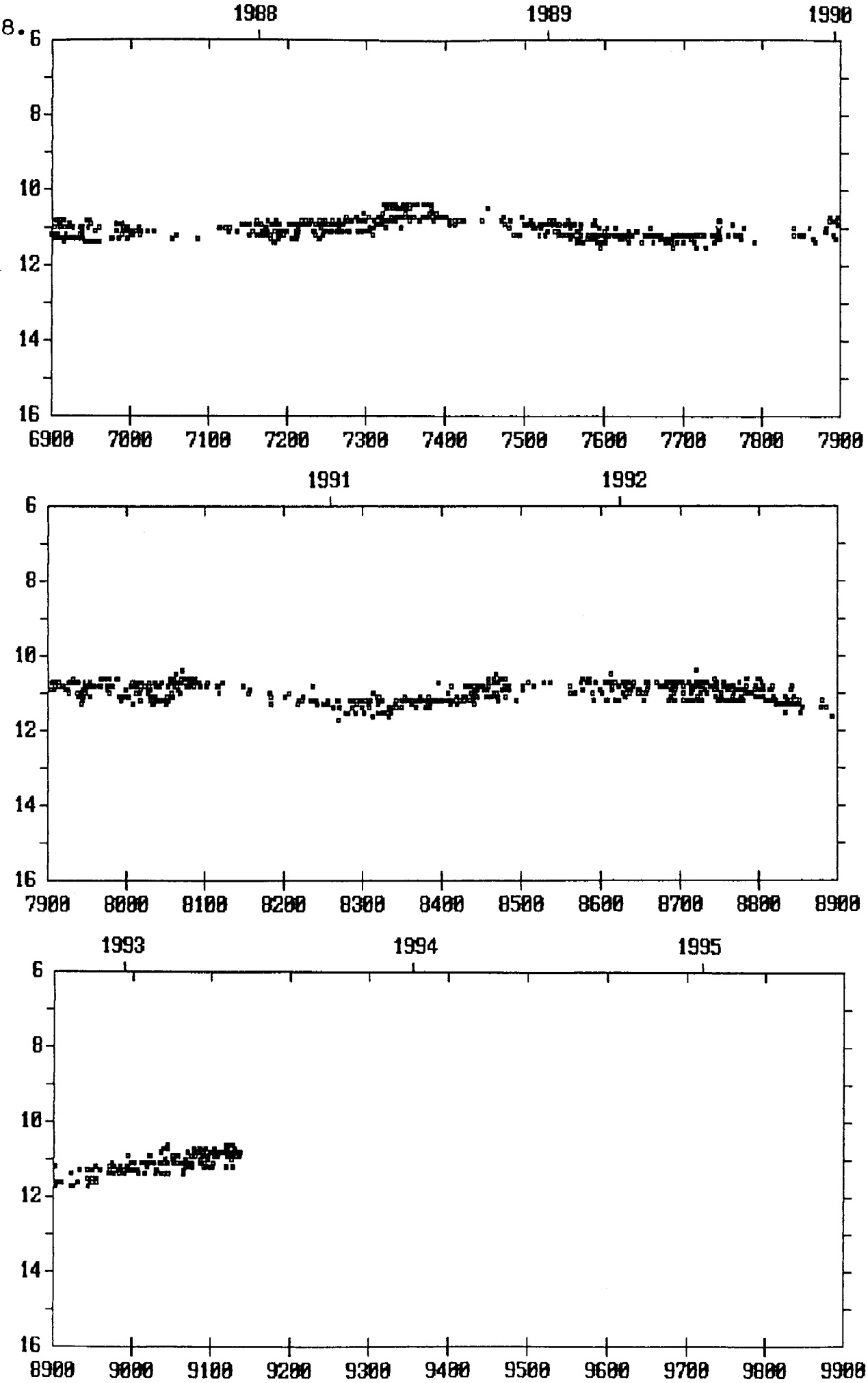

SY MUSCAE

FIGURE 3
Light Curve from Individual Observations
J.D. 2,440,900 - J.D. 2,443,900




SY MUSCAE

FIGURE 4
Light Curve from Individual Observations
J.D. 2,443,900 - J.D. 2,446,900




SY MUSCAE

FIGURE 5
Light Curve from Individual Observations
J.D. 2,446,900 - J.D. 2,449,137

# OUTBURSTS OF THE DWARF NOVA TW VIRGINIS

Frank M. Bateson, Albert F. Jones & Ranald McIntosh

SUMMARY: A total of 203 outbursts of TW Vir are listed. A section of the light curve is reproduced with diagrams showing the spread in maximum magnitudes, widths at maximum and the distribution of intervals between maxima that are probably consecutive. The outburst cycle is 33.3 days.

- - - - - -

## 1. INTRODUCTION

TW Vir is a dwarf nova, type U Gem, with a range in V of 12.1 to 15.8 with an outburst cycle of 15 to 44 days and orbital period of 0.18267d (1). It is also a X-ray source - PG 1142-041.

## 2. OBSERVATIONS

The observations discussed cover the interval March 9, 1955 to August 13, 1990. They were all made visually by members of the Variable Star Section, R.A.S.N.Z.

Charts 134/5 were published (2) with comparison stars brighter than 8.6 having $SP_v$ or Hptm magnitudes. The fainter comparison stars were denoted by letters. It was quickly found that TW Vir had been plotted slight S.W. of its correct position and a correction was made on these charts. These charts were replaced by Nos. 330/1 (3) showing the AAVSO sequence. All observations have been reduced to this sequence.

Table 1 lists the dates of maxima of outbursts in the usual format. Two portions of the light curve are shown in Figs.1 and 2.

Fig. 3 shows the number of outbursts for each maximum magnitude. Only reliably determined magnitudes from Table 1 have been used.

Fig. 4 shows outbursts for which the width of maximum could be accurately determined in days at 13.0 I-D. Fig 5 shows the distribution of intervals between maxima that were probably consecutive.

## 3. DISCUSSION

TW Vir has been closely monitored during its observing season, but estimates are limited at the beginning and end of the observing season when the variable is low in the sky.

This accounts for most of the long intervals between maxima enclosed in brackets in column 4 of Table 1.

The mean magnitude at maximum is 12.4, derived from those values in column 2 of Table 1. The number of maxima with peak brightness from 11.3 to 13.5 is shown in Fig. 3 which shows clearly that the majority fall between 12.0 and 12.7

Column 7 of Table 1 lists, when possible, the widths of maxima measured as the intervals between magnitude 13.0 on the rise and decline. These are merely the top segment of the light curve when TW Vir was brighter than 13.0. The reliability of these widths depends on there being sufficient observations on both the rising and falling branches of the light curve. The last column lists the number of estimates used to determine widths. Fig. 4 shows the number of maxima having widths between 1 and 11 days. The mean is 3.6 days. There is a tendancy for the brightest maxima to have the widest widths despite this not being true in all cases.

The distribution of intervals between maxima which are probably consecutive is illustrated in Fig. 5. These are also shown in column 4 of Table 1, with uncertain intervals followed by a question mark and intervals that are obviously not consecutive enclosed in brackets. Both of these values have been excluded from Fig. 5.

The mean outburst cycle from Fig. 5 is 33.3 days. This is reduced to 30.8 days if only intervals of 50 days or less are considered to be consecutive, whereas if all intervals in Table 1 that may possibly be consecutive are included, the mean cycle becomes 36.3 days. However, we consider the correct mean cycle is 33.3 days.

## 4. CONCLUSIONS

TW Vir is a U Gem type variable with a short mean outburst cycle of 33.3 days. The mean magnitude at maximum is 12.4. Maxima are short with a mean width of 3.6 days at magnitude 13.0. Minima are fainter than 15.0.

## ACKNOWLEDGEMENTS

This paper has only been possible by the decades of careful monitoring of TW Vir by most members of the Variable Star Section. Our thanks are due to Maureen Phizacklea for her care in typing and checking of Table 1.

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TABLE 1

TW VIRGINIS - OBSERVED OUTBURSTS 1955-1991

| No. | Max Mag.-v | J.D. Max 24 ..... | Int. d | 13.0 R | 13.0 D | Width 13.0 I-D d | No. Obs. |
|---|---|---|---|---|---|---|---|
| 1 | 12.6 | 35,182 | - | 35,181 | 35,183 | 2 | 5 |
| 2 | 13.0? | 228? | 46? | - | - | - | 1 |
| 3 | 13.1? | 236? | 8? | - | - | - | 2 |
| 4 | 12.5 | 266? | 30? | - | - | - | 1 |
| 5 | 12.4 | 288 | 22 | - | - | - | 1 |
| 6 | 12.3 | 488 | (200) | 486 | 491? | 5? | 8 |
| 7 | 12.5 | 514? | 26? | - | - | - | 1 |
| 8 | 12.1 | 667? | (153) | 566 | 568 | 2 | 3 |
| 9 | 13.1 | 900 | (233) | - | - | - | 4 |
| 10 | 12.0 | 936 | 36 | 934 | ? | ? | 2 |
| 11 | 12.1 | 999 | 63 | 995 | 004 | 9 | 7 |
| 12 | 12.4 | 36,261 | (262) | 261 | 265 | 4 | 5 |
| 13 | 11.8 | 294 | 33 | 293 | 299 | 6 | 4 |
| 14 | 12.2 | 319 | 25 | 318 | 321 | 3 | 4 |
| 15 | 12.9 | 340 | 21 | 340 | 341 | 1 | 2 |
| 16 | 12.9 | 361 | 21 | - | - | - | 1 |
| 17 | 12.0 | 388 | 27 | ? | 389 | ? | 2 |
| 18 | 12.1 | 416 | 28 | ? | 418 | - | 2 |
| 19 | 13.5? | 585? | (169) | - | - | - | 1 |
| 20 | 12.2 | 607 | 22? | ? | 609 | - | 3 |
| 21 | 12.3 | 634 | 27 | 633 | 635 | 2 | 3 |
| 22 | 11.8 | 661 | 27 | 659 | 664 | 5 | 6 |
| 23 | 13.3 | 697 | 36 | - | - | - | 2 |
| 24 | 13.5 | 718 | 21 | - | - | - | 1 |
| 25 | 12.1 | 738 | 20 | 738 | ? | - | 2 |
| 26 | 11.3 | 902 | (164) | ? | ? | - | 1 |
| 27 | 12.1 | 934 | 32 | ? | 936 | - | 2 |
| 28 | 11.4 | 989 | 55 | 988 | 995 | 7 | 6 |
| 29 | 12.2 | 37,029 | 40 | ? | ? | - | 1 |
| 30 | 11.7 | 110 | ( 81) | 108 | 116 | 8 | 5 |
| 31 | 11.8 | 289 | (179) | 285 | 290 | 5 | 3 |
| 32 | 12.1 | 339 | 50 | - | - | - | 1 |
| 33 | 11.9 | 386 | 47 | 384 | ? | - | 3 |
| 34 | 11.8 | 436 | 50 | ? | 439 | - | 3 |
| 35 | 11.8 | 485 | 49 | 482 | 486 | 4 | 4 |
| 36 | 12.4 | 682 | (197) | ? | ? | - | 2 |
| 37 | 12.3 | 761 | ( 79) | 758 | 764 | 6 | 6 |
| 38 | 12.4 | 824 | 63 | ? | 825 | - | 2 |
| 39 | 12.3 | 38,006 | (182) | ? | ? | - | 1 |
| 40 | 12.3 | 032 | 26 | 031 | 034 | 3 | 3 |

TABLE 1 (Cont.)

TW VIRGINIS - OBSERVED OUTBURSTS 1955-1991

| No. | Max Mag.v | J.D. Max 24 ..... | Int. a | 13.0 R | 13.0 D | Width 13.0 I-D a | No. Obs. |
|---|---|---|---|---|---|---|---|
| 41 | 11.9 | 38,103 | 71 | 102 | 110 | 8 | 9 |
| 42 | 12.4 | 159 | 56 | ? | 162 | - | 5 |
| 43 | 12.4 | 200 | 41 | 197 | 203 | 6 | 4 |
| 44 | 13.4? | 403? | (203?) | - | - | - | 1 |
| 45 | 12.3 | 443 | 40 | - | - | - | 1 |
| 46 | 13.3? | 794 | (351) | - | - | - | 1 |
| 47 | 13.0 | 817 | 23 | - | - | - | 1 |
| 48 | 12.6 | 854 | 37 | 853 | 855 | 2 | 3 |
| 49 | 12.3 | 878 | 24 | 877 | 884 | 7 | 6 |
| 50 | 12.4 | 915 | 37 | - | - | - | 1 |
| 51 | 12.5 | 935 | 20 | - | - | - | 2 |
| 52 | 12.5 | 960 | 25 | - | - | - | 1 |
| 53 | 12.5 | 39,151 | (191) | 150 | 153 | 3 | 3 |
| 54 | 12.4 | 201 | 50 | 198 | 203 | 5 | 4 |
| 55 | 12.2 | 283 | 82 | 282 | 284 | 2 | 3 |
| 56 | 12.6 | 331? | 48 | - | - | - | 1 |
| 57 | 12.6 | 507 | (176) | - | - | - | 1 |
| 58 | 11.9 | 533 | 26 | 532 | 535 | 3 | 4 |
| 59 | 12.4 | 568 | 35 | 567 | - | ? | 2 |
| 60 | 12.6 | 615 | 47 | 615 | 617 | 2 | 3 |
| 61 | 12.5 | 667 | 52 | 666 | 670 | 4 | 3 |
| 62 | 11.9 | 894 | (227) | 894 | 898 | 4 | 4 |
| 63 | 11.9 | 972 | ( 78) | 971 | 976 | 5 | 7 |
| 64 | 12.5 | 40,028 | 56 | - | - | - | 1 |
| 65 | 12.1 | 216 | (188) | - | - | - | 2 |
| 66 | 13.4? | 283? | 67 | - | - | - | 1 |
| 67 | 12.1 | 324 | 41 | 323 | 330 | 7 | 8 |
| 68 | 12.3 | 366 | 42 | 366 | ? | - | 3 |
| 69 | 12.3 | 436 | 70 | 435 | 440 | 5 | 6 |
| 70 | 12.3 | 619 | (183) | 618 | 620 | 2 | 2 |
| 71 | 11.9 | 730 | (111) | 729 | 737 | 8 | 9 |
| 72 | 13.6? | 926 | (196) | - | - | - | 1 |
| 73 | 12.2 | 41,008 | 82 | 007 | ? | - | 2 |
| 74 | 12.3 | 045 | 37 | 044 | 046 | 2 | 2 |
| 75 | 12.2 | 066 | 21 | 066 | 067 | 1 | 7 |
| 76 | 12.3 | 083 | 17 | 082 | 084 | 2 | 3 |
| 77 | 12.1 | 343 | (260) | - | - | - | 1 |
| 78 | 11.9 | 417 | 74 | 416 | 424 | 8 | 12 |
| 79 | 11.9 | 455 | 38 | 455 | 457 | 2 | 7 |
| 80 | 12.4 | 494 | 39 | 494 | ? | - | 2 |

TABLE 1 (Cont.)

TW VIRGINIS - OBSERVED OUTBURSTS 1955-1991

| No. | Max Mag.-v | J.D. Max 24 ..... | Int. d | 13.0 R | 13.0 D | Width 13.0 I-D d | No. Obs. |
|---|---|---|---|---|---|---|---|
| 81 | 11.9 | 529 | 35 | 527 | 533 | 6 | 9 |
| 82 | 12.7? | 695? | (166) | - | - | - | 1 |
| 83 | 12.1 | 728 | 33 | - | - | - | 2 |
| 84 | 12.1 | 758 | 30 | 757 | 765 | 8 | 7 |
| 85 | 12.5 | 791 | 33 | 791 | 794 | 3 | 3 |
| 86 | 12.0 | 844 | 53 | 844 | 847 | 3 | 10 |
| 87 | 12.6 | 874 | 30 | 874 | 878 | 4 | 5 |
| 88 | 12.5? | 42,009? | (135) | - | - | - | 1 |
| 89 | 12.4 | 025? | 16? | - | - | - | 1 |
| 90 | 12.2 | 102 | 77? | 100 | 104 | 4 | 3 |
| 91 | 12.7? | 119? | 17? | - | - | - | 1 |
| 92 | 11.9 | 132 | 13? | 130 | 134 | 4 | 8 |
| 93 | 12.4 | 154 | 22 | 153 | 156 | 3 | 9 |
| 94 | 12.3 | 177 | 23 | 177 | 180 | 3 | 5 |
| 95 | 12.0 | 201 | 24 | 200 | 203 | 3 | 4 |
| 96 | 12.5 | 222 | 21 | 221 | 224 | 3 | 11 |
| 97 | 12.5 | 246 | 24 | 245 | 248 | 3 | 11 |
| 98 | 12.4 | 270 | 24 | 269 | 271 | 2 | 6 |
| 99 | 12.9? | 403? | (133) | - | - | - | 3 |
| 100 | 12.3 | 463 | 60? | 462 | 467 | 5 | 8 |
| 101 | 12.1 | 509 | 46 | 508 | 511 | 3 | 15 |
| 102 | 12.1 | 546 | 37 | 546 | 549 | 3 | 8 |
| 103 | 12.5 | 562 | 16 | 562 | 563 | 1 | 6 |
| 104 | 12.4 | 598 | 36 | 598 | 600 | 2 | 5 |
| 105 | 12.3 | 621 | 23 | 621 | 623 | 2 | 8 |
| 106 | 13.1? | 775? | (154) | - | - | - | 1 |
| 107 | 12.0 | 833 | 58? | 832 | 837 | 5 | 10 |
| 108 | 12.2 | 865 | 32 | 864 | 867 | 3 | 6 |
| 109 | 12.3 | 888 | 23 | 888 | 890 | 2 | 9 |
| 110 | 13.0? | 914? | 26? | - | - | - | 2 |
| 111 | 12.5 | 952 | 38? | 951 | 954 | 3 | 5 |
| 112 | 12.5 | 43,174 | (222) | 174 | ? | - | 4 |
| 113 | 12.2 | 244 | 70 | 244 | 247 | 3 | 7 |
| 114 | 12.0 | 283 | 39 | 282 | 286 | 4 | 8 |
| 115 | 12.0 | 356 | 73 | 355 | 362 | 7 | 6 |
| 116 | 12.4 | 567 | (211) | 567 | 578 | 11 | 13 |
| 117 | 11.9 | 623 | 56 | 622 | 625 | 3 | 6 |
| 118 | 12.0 | 673 | 50 | 673 | ? | ? | 2 |
| 119 | 12.5 | 715 | 42 | ? | ? | ? | 2 |
| 120 | 12.5? | 927? | (212) | - | - | - | 2 |

TABLE 1 (Cont.)

TW VIRGINIS - OBSERVED OUTBURSTS 1955-1991

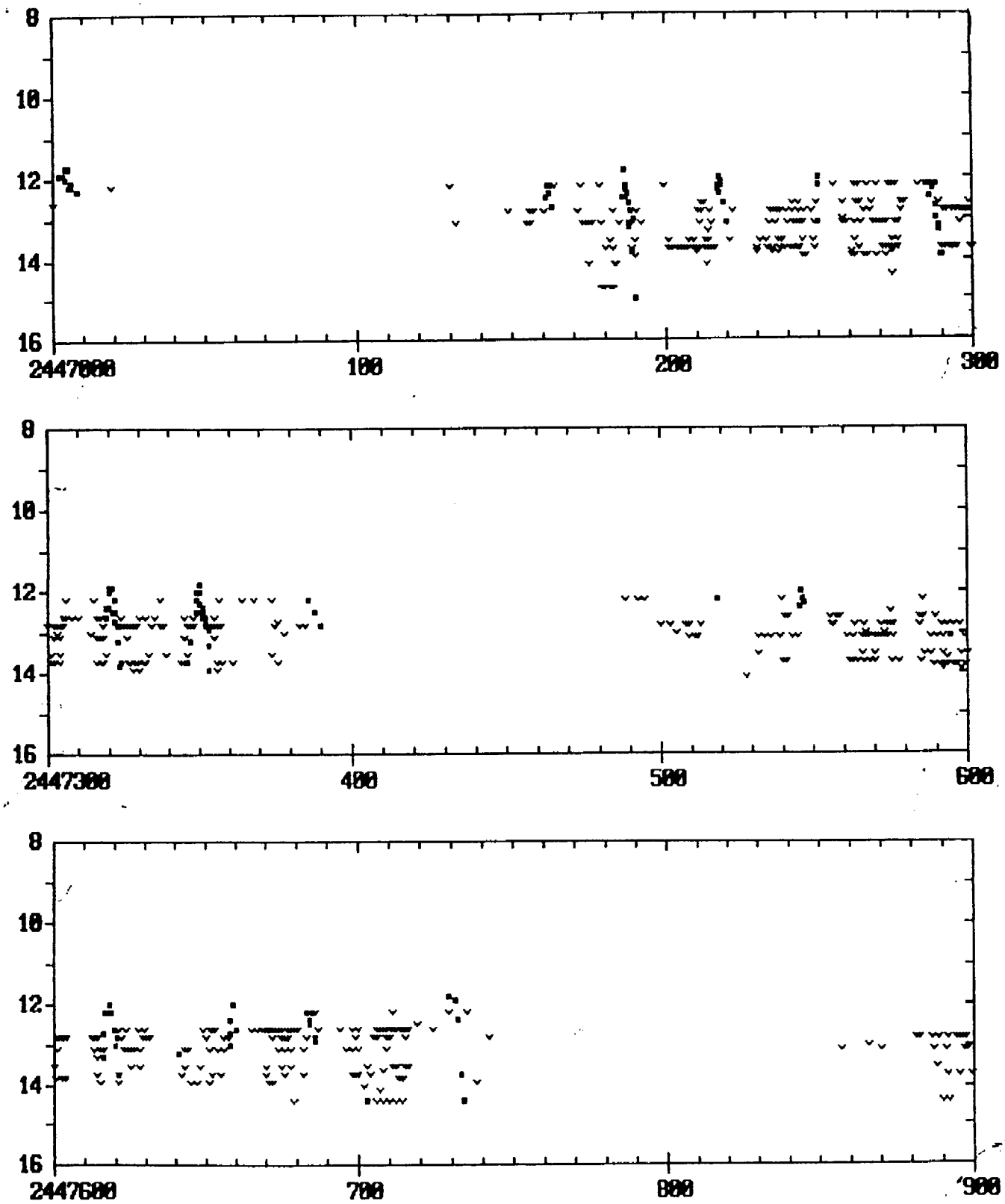
| No. | Max Mag.v | J.D. Max 24 ..... | Int. d | 13.0 R | 13.0 D | Width 13.0 I-D d | No. Obs. |
|---|---|---|---|---|---|---|---|
| 121 | 12.5 | 957 | 30 | 957 | 959 | 2 | 5 |
| 122 | 12.2 | 994 | 37 | 993 | 995 | 2 | 10 |
| 123 | 12.4 | 44,023 | 29 | 022 | 028 | 6 | 14 |
| 124 | 12.5 | 059 | 36 | 058 | 062 | 4 | 5 |
| 125 | 13.1? | 079? | 20 | – | – | – | 2 |
| 126 | 12.0 | 100 | 21 | 099 | ? | ? | 1 |
| 127 | 12.7? | 229? | (129?) | – | – | – | 1 |
| 128 | 12.6 | 286 | 57 | 286 | 287 | 1 | 5 |
| 129 | 11.9 | 317 | 31 | 316 | 319 | 3 | 16 |
| 130 | 12.5 | 343 | 26 | 343 | 345 | 2 | 5 |
| 131 | 11.9 | 377 | 34 | 376 | 382 | 6 | 13 |
| 132 | 13.1 | 427 | 50 | – | – | – | 4 |
| 133 | 12.4 | 466 | 39 | 466 | 468 | 2 | 4 |
| 134 | 13.0? | 648? | (182) | – | – | – | 3 |
| 135 | 12.0 | 672 | 24? | 671 | 673 | 2 | 3 |
| 136 | 12.2 | 701 | 29 | 701 | 703 | 2 | 10 |
| 137 | 12.3 | 727 | 26 | 727 | 729 | 2 | 10 |
| 138 | 12.4 | 748 | 21 | 748 | 750 | 2 | 12 |
| 139 | 12.2 | 779 | 31 | 779 | 781 | 2 | 9 |
| 140 | 12.4 | 807 | 28 | 806 | 809 | 3 | 6 |
| 141 | 11.9 | 45,007 | (200) | 006 | ? | ? | 2 |
| 142 | 12.6? | 060? | 53? | 059 | ? | ? | 2 |
| 143 | 11.9 | 082 | 22? | 081 | 084 | 3 | 14 |
| 144 | 12.2 | 119 | 37 | 117 | 120 | 3 | 5 |
| 145 | 12.4 | 138 | 19 | 138 | 141 | 3 | 10 |
| 146 | 12.4 | 161 | 23 | 161 | 162 | 1 | 6 |
| 147 | 12.0 | 314? | (153) | – | – | – | 1 |
| 148 | 12.8 | 355 | 41? | 354 | 357 | 3 | 2 |
| 149 | 12.2 | 378 | 23 | 378 | 380 | 2 | 10 |
| 150 | 12.4 | 398 | 20 | 398 | 399 | 1 | 5 |
| 151 | 12.2 | 438 | 40 | 438 | 440 | 2 | 7 |
| 152 | 12.3 | 458 | 20 | 458 | 459 | 1 | 10 |
| 153 | 12.6 | 473 | 15 | 472 | 474 | 2 | 3 |
| 154 | 12.9 | 489 | 16 | 487 | 489 | 2 | 5 |
| 155 | 12.6 | 526 | 37 | 526 | 528 | 2 | 3 |
| 156 | 12.5 | 545 | 19 | 545 | 546 | 1 | 3 |
| 157 | 12.2 | 736 | (191) | 735 | 738 | 3 | 5 |
| 158 | 12.5 | 753 | 17 | 753 | 755 | 2 | 3 |
| 159 | 12.1 | 808 | 55 | 807 | 815 | 8 | 12 |
| 160 | 12.2 | 851 | 43 | 850 | 855 | 5 | 10 |

TABLE 1 (Cont.)

TW VIRGINIS - OBSERVED OUTBURSTS 1955-1991

| No. | Max Mag.v | J.D. Max 24 ..... | Int. d | 13.0 R | 13.0 D | Width 13.0 I-D d | No. Obs. |
|---|---|---|---|---|---|---|---|
| 161 | 11.9 | 902 | 51 | 900 | 903 | 3 | 7 |
| 162 | 12.2 | 46,026 | (124) | – | – | – | 1 |
| 163 | 12.7? | 057 | 31 | 057 | 059 | 2 | 2 |
| 164 | 12.0 | 081 | 24 | 080 | ? | ? | 2 |
| 165 | 12.0 | 111 | 30 | 110 | 115 | 5 | 4 |
| 166 | 12.5 | 143 | 32 | 143 | 146 | 3 | 17 |
| 167 | 11.7 | 229 | 86 | 226 | 235 | 9 | 22 |
| 168 | 12.6? | 410? | (181) | – | – | – | 1 |
| 169 | 12.0 | 438 | 28? | 437 | 441 | 4 | 8 |
| 170 | 12.2 | 465 | 27 | 464 | 467 | 3 | 16 |
| 171 | 12.2 | 490 | 25 | 489 | 492 | 3 | 5 |
| 172 | 11.9 | 531 | 41 | 530 | 538 | 8 | 14 |
| 173 | 11.8 | 575 | 44 | 573 | 578 | 5 | 8 |
| 174 | 12.0 | 627 | 52 | 627 | 630 | 3 | 4 |
| 175 | 12.3 | 805 | (178) | 803 | 807 | 4 | 4 |
| 176 | 12.0 | 827 | 22 | 826 | 829 | 3 | 9 |
| 177 | 12.2 | 854 | 27 | 852 | 856 | 4 | 9 |
| 178 | 12.5 | 911? | 57 | – | – | – | 1 |
| 179 | 12.6 | 961 | 50? | – | – | – | 1 |
| 180 | 11.9 | 47,002 | 41 | 002 | 008 | 6 | 9 |
| 181 | 12.2 | 161 | (159) | 161 | 163 | 2 | 5 |
| 182 | 11.8 | 186 | 25 | 185 | 189 | 4 | 14 |
| 183 | 12.0 | 217 | 31 | 217 | 220 | 3 | 8 |
| 184 | 12.2 | 250 | 33 | 250 | 256 | 6 | 4 |
| 185 | 12.2 | 285 | 35 | 284 | 288 | 4 | 12 |
| 186 | 11.9 | 320 | 35 | 319 | 323 | 4 | 16 |
| 187 | 12.0 | 349 | 29 | 349 | 352 | 3 | 22 |
| 188 | 12.2 | 386 | 37 | 385 | 390 | 5 | 3 |
| 189 | 12.2 | 518? | (132) | – | – | – | 1 |
| 190 | 12.0 | 546 | 28? | 545 | 547 | 2 | 4 |
| 191 | 12.0 | 617 | 71 | 616 | 620 | 4 | 10 |
| 192 | 13.2? | 635? | 18? | – | – | – | 2 |
| 193 | 12.0 | 659 | 24? | 658 | 660 | 2 | 5 |
| 194 | 12.2 | 683 | 24 | 683 | 686 | 3 | 6 |
| 195 | 11.8 | 729 | 46 | 729 | 732 | 3 | 5 |
| 196 | 11.8 | 913 | (184) | 912 | 914 | 2 | 3 |
| 197 | 12.6 | 950 | 37 | 949 | 952 | 3 | 8 |
| 198 | 12.0 | 974 | 24 | 974 | 977 | 3 | 4 |
| 199 | 11.9 | 48,003 | 29 | 002 | 006 | 4 | 8 |
| 200 | 11.8 | 025 | 22 | 024 | 027 | 3 | 9 |
| 201 | 12.0 | 043 | 18 | 042 | 046 | 4 | 3 |
| 202 | 12.4 | 062 | 19 | 062 | 065 | 3 | 8 |
| 203 | 12.6 | 085 | 23 | 084 | 087 | 3 | 5 |

. . . . . .




TW VIR

FIGURE 1

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,447,000 - 2,447,900

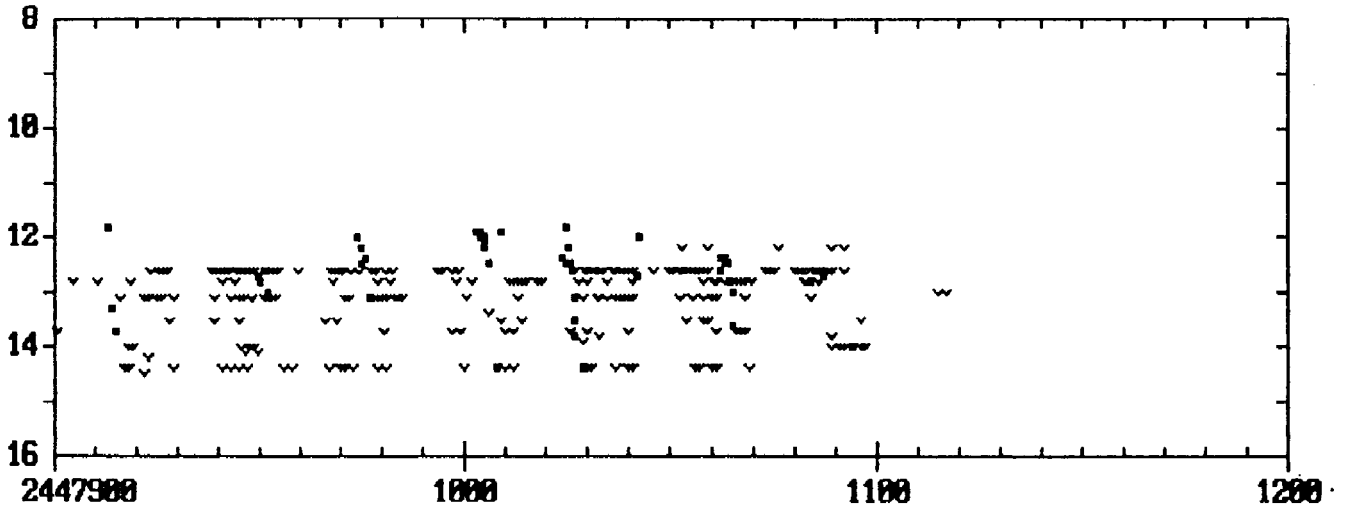



FIGURE 2

TW VIR LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS
J.D. 2,447,900 - 2,448,117

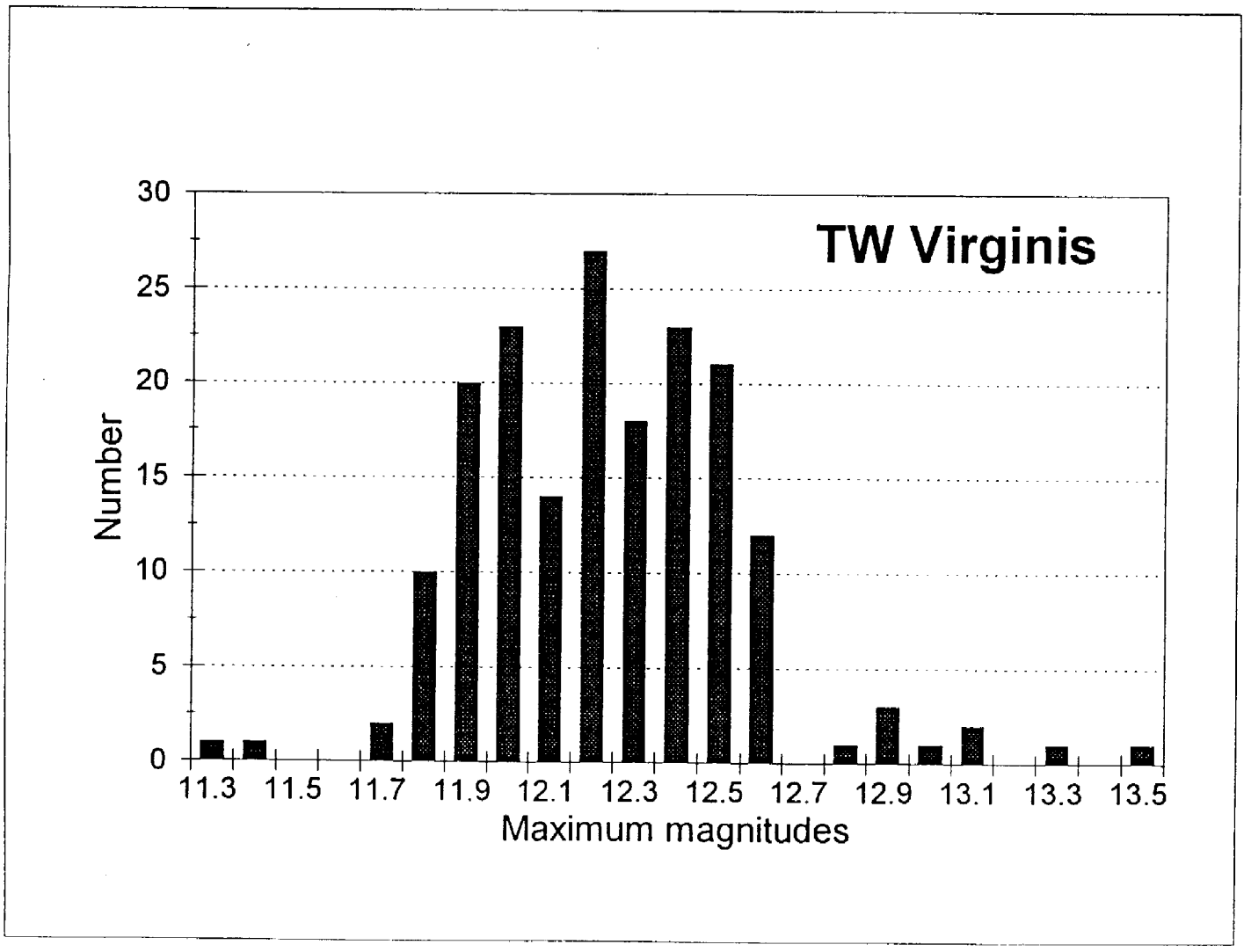



FIGURE 3
NUMBER OF OUTBURSTS FOR EACH MAXIMUM MAGNITUDE

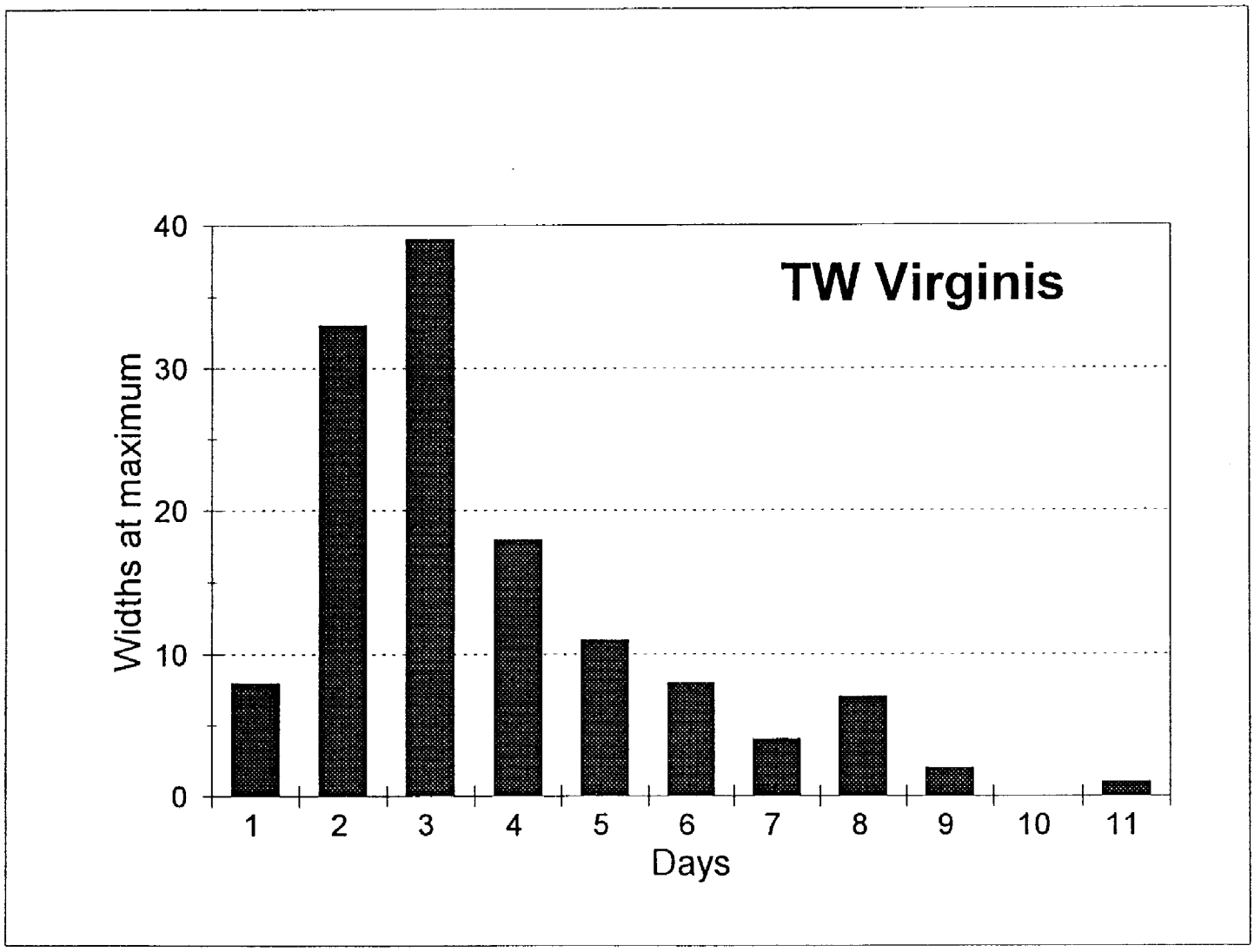



FIGURE 4

NUMBER OF OUTBURSTS FOR EACH WIDTH, IN DAYS, BETWEEN 13.0 I - D.

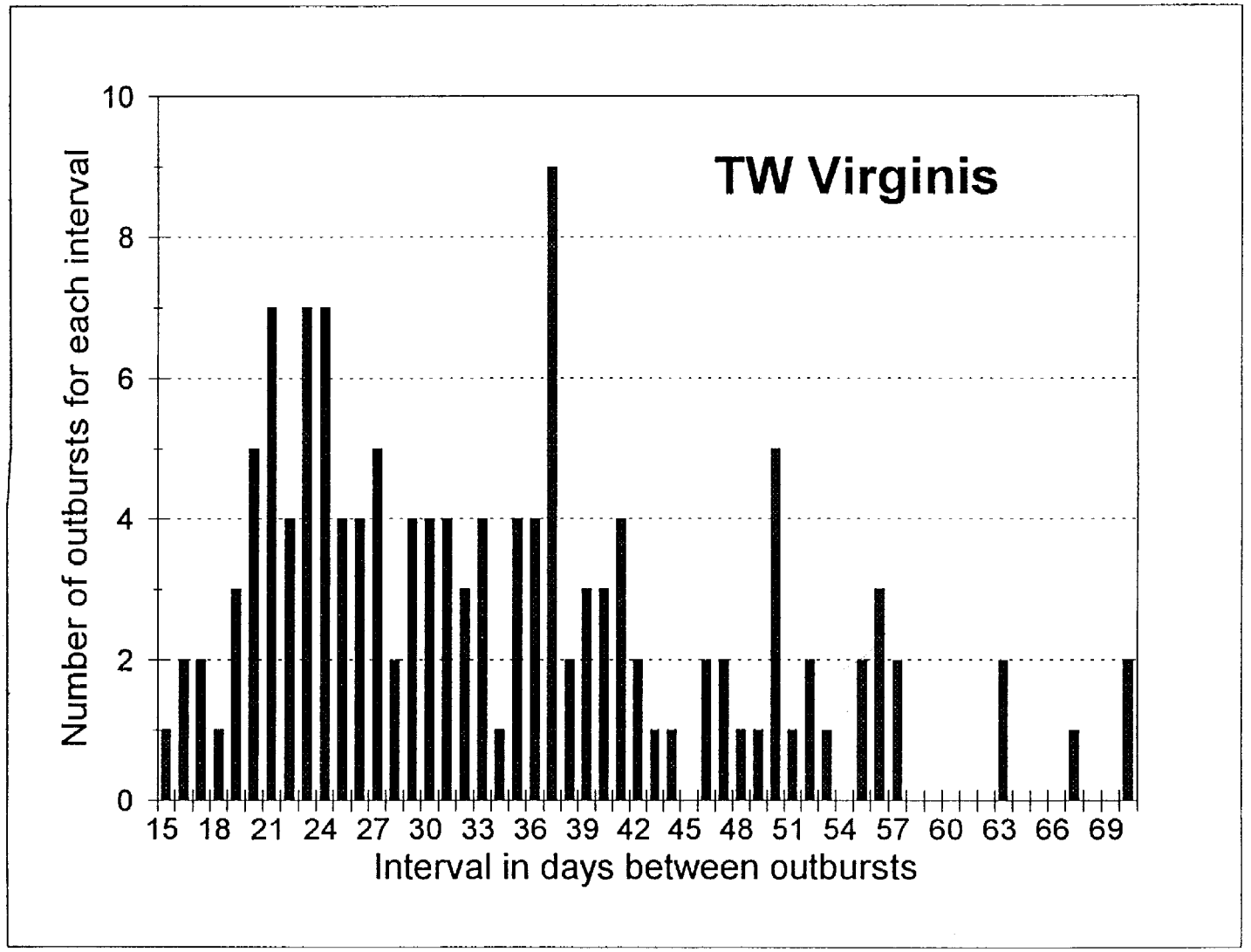



FIGURE 5

NUMBER OF OUTBURSTS FOR EACH INTERVAL, IN DAYS, BETWEEN MAXIMA THAT WERE PROBABLY CONSECUTIVE.

# VISUAL VARIATIONS OF HD 5980

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*SUMMARY:* *Distinct variations in the brightness of HD 5980 are reported. Small increases occurred in 1989 and 1991 with a short sharp rise of one magnitude in late 1993. The star then returned to its normal magnitude before increasing two magnitudes to its current 1994 outburst. HD 5980 is also an eclipsing binary with a possible period of about 22 days.*

## 1. INTRODUCTION

HD 5980 (RA 00h $59_m$ $28_s$. Dec $-72^o$ 9'.8. Equinox 2000) is in the SMC. Feast, Thackeray & Wesselink (1) gave details of the spectrum, listing it as PEC? Occasional P Cyg structure was noted. They quote Gascoigne as giving the values: V = 11.77; B-V = -0.20; U-B = -0.99. Their paper included a finder chart.

HD 5980 lies within NGC 346. It is also known as Radcliffe 14,(R 14); Hen S28B. R. Barba & V. Niemela I.A.U. circular No. 6099 (2) recently drew attention to a brightening and to strong P Cyg lines in its spectra. They suggested that HD 5980 had undergone a Eta Car type outburst.

## 2. OBSERVATIONS

One of us (A.F.J.) commenced observing HD 5980 on J.D. 2,446,995 (1987 July 18). He considered the estimates prior to J.D. 2,447,053 as unreliable. Visual estimates since that date have been made using V magnitude stars. The observations have been summarised each month since that date in the Monthly Circulars of the V.S.S., R.A.S.N.Z.

Table 1 lists the means for each 50 observations and also gives the visual range for each 50 estimates. Portions of the light curve are shown in Figs. 1 to 2.

## 3. DISCUSSION

All the observations were made by a very experienced visual observer. They therefore represent a homogeneous set of data despite that this star is a difficult object to observe visually due to the background of nebulosity. However, the aim of the observations was to detect any unusual behaviour in HD 5980.

It appears from the light curve and from Table 1 that the brightness has not remained stable. There was a distinct short rise in 1989 and a more prolonged brightening in 1991 This was followed in 1992 by a distinct fading.

There was a short sharp rise of one magnitude in late 1993 from which the star briefly returned to its normal brightness before sharply rising two magnitudes to its current 1994 outburst.

The observations also make it obvious that HD 5980 is an eclipsing binary. It is extremely difficult to exactly determine the exact points of mid-eclipse. This is due to the estimates being scattered in time and sometimes affected by seeing conditions. However, Table 2 lists possible dates at, or close to mid eclipse, and the magnitude at these times. These indicate that the period may be about 22 days. The lack in most cases of estimates on the descent to and rise from mid-eclipse means that the dates in Table 2 are uncertain as the normal tracing paper method, combined with the small range, made it impossible to apply this method. This problem should be solved with photoelectric observations which Grant Christie has kindly undertaken.

## 4. CONCLUSIONS

HD 5980 is not a Wolf-Rayet variable but appears to be of the S Dor type. Its mean magnitude has risen from 11.03 in 1988 to 8.65 in 1994. The corresponding extreme ranges are 10.5 - 11.6 and 7.9 - 9.4. It is also an eclipsing binary with a possible eclipse period of about 22 days but this must be regarded with caution because the small range in any particular year makes it difficult to decide which estimates are at, or close to mid eclipse, especially as there are insufficient observations on each branch of the eclipse curve.

The exact eclipse period will be determined from photoelectric data now being obtained.

## ACKNOWLEDGEMENTS

All observations were made by Albert F. Jones, whilst Frank Bateson is responsible for this discussion, any defects in which are his responsibility. We thank Ranald McIntosh for the computer light curve.

## REFERENCES:

(1) M.W. Feast, A.D. Thackeray & A.J. Wesselink, 1960. Mon. Not. R.astr. Soc. Vol. 121, No. 4, pp 337-385.

(2) R. Barba & V. Niemela, 1994. IAU Circ. 6099.

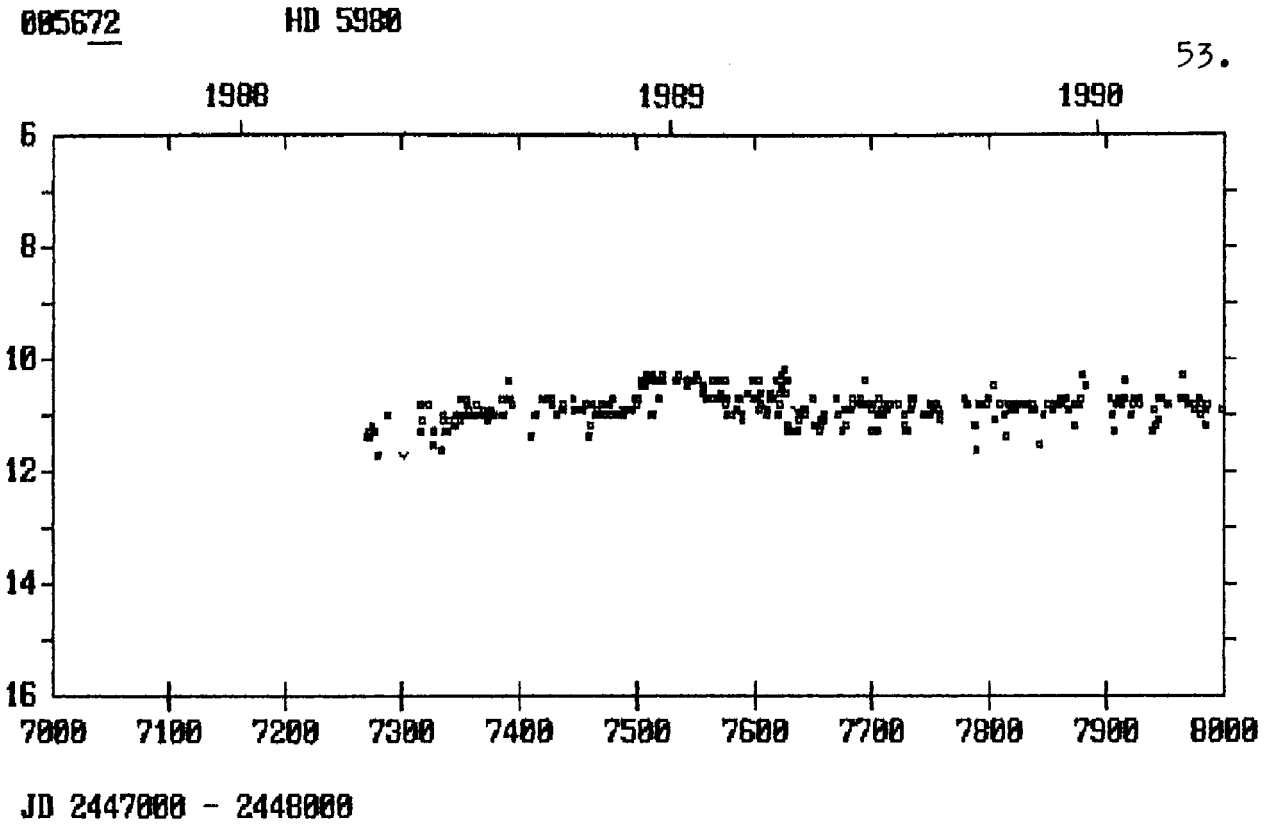
TABLE 1
HD 5980 - MEANS

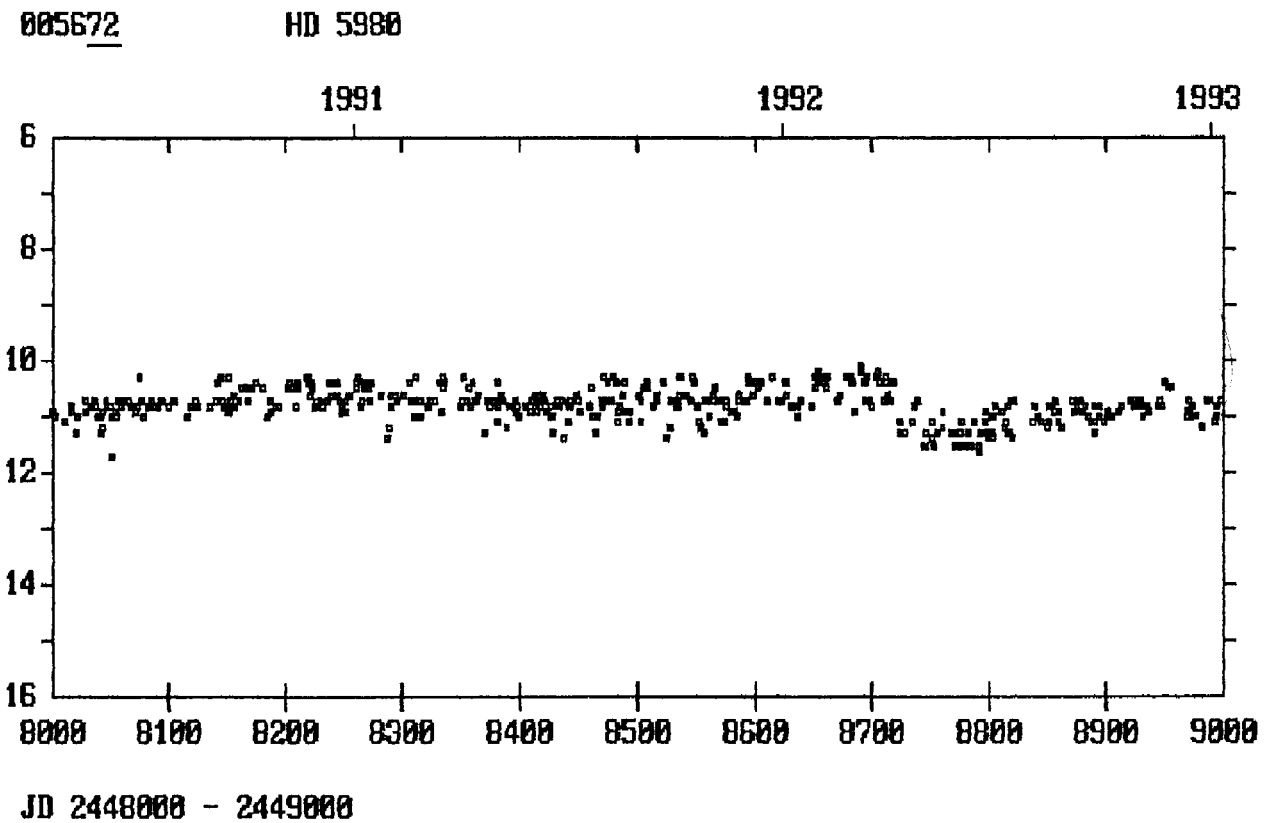
| J.D. | Mean $Mag_v$ | Range $Mag_v$ | Remarks |
|---|---|---|---|
| 2447,102 | 11.03 | 10.5 - 11.3 | (1) |
| 239 | 10.97 | 10.5 - 11.3 | |
| 316 | 11.05 | 10.7 - 11.6 | |
| 425 | 10.98 | 10.4 - 11.6 | |
| 513 | 10.82 | 10.3 - 11.4 | |
| 610 | 10.62 | 10.3 - 11.0 | |
| 706 | 10.87 | 10.2 - 11.3 | |
| 819 | 10.91 | 10.5 - 11.6 | |
| 942 | 10.81 | 10.3 - 11.5 | |
| 2448,052 | 10.87 | 10.3 - 11.7 | |
| 168 | 10.73 | 10.3 - 11.0 | |
| 264 | 10.59 | 10.3 - 11.0 | |
| 383 | 10.67 | 10.3 - 11.4 | |
| 471 | 10.82 | 10.6 - 11.4 | |
| 564 | 10.70 | 10.3 - 11.3 | |
| 681 | 10.60 | 10.2 - 11.1 | |
| 778 | 10.86 | 10.1 - 11.5 | |
| 891 | 11.05 | 10.7 - 11.6 | |
| 2449,004 | 10.82 | 10.4 - 11.1 | |
| 106 | 10.83 | 10.4 - 11.3 | |
| 207 | 11.00 | 10.6 - 11.3 | |
| 282 | 10.92 | 10.7 - 11.4 | |
| 367 | 9.93 | 9.4 - 11.1 | |
| 473 | 10.74 | 10.3 - 11.4 | |
| 562 | 9.78 | 8.8 - 11.1 | |
| 608 | 8.65 | 7.9 - 9.4 | |

(1) Observations (19) to 7054 not considered reliable by AFJ

TABLE 2
HD 5980 - OBSERVATIONS POSSIBLE AT, OR CLOSE TO, MID-ECLIPSE

| J.D. | $Mag_v$ | Int.a |
|---|---|---|
| 2447,312.24 | 11.6 | - |
| 334.21 | 11.6 | 21.97 |
| 788.91 | 11.6 | ( 454.70 ) |
| 2448,790.23 | 11.6 | (1001.32 ) |
| 819.26? | 11.4? | 29.03? |
| 849.87? | 11.2? | 30.61? |
| 890.22? | 11.3? | ( 40.35?) |
| 981.92? | 11.2? | ( 91.70?) |
| 2449,027.89? | 11.1? | ( 45.97?) |
| 053.87? | 11.1? | 25.98? |
| 074.84? | 11.1? | 20.97? |
| 131.23? | 11.3? | ( 56.39?) |
| 157.24? | 11.3? | 26.01? |
| 243.98 | 11.3 | ( 86.74 ) |
| 264.19 | 11.4 | 20.21 |
| 287.91 | 11.1 | 23.72 |



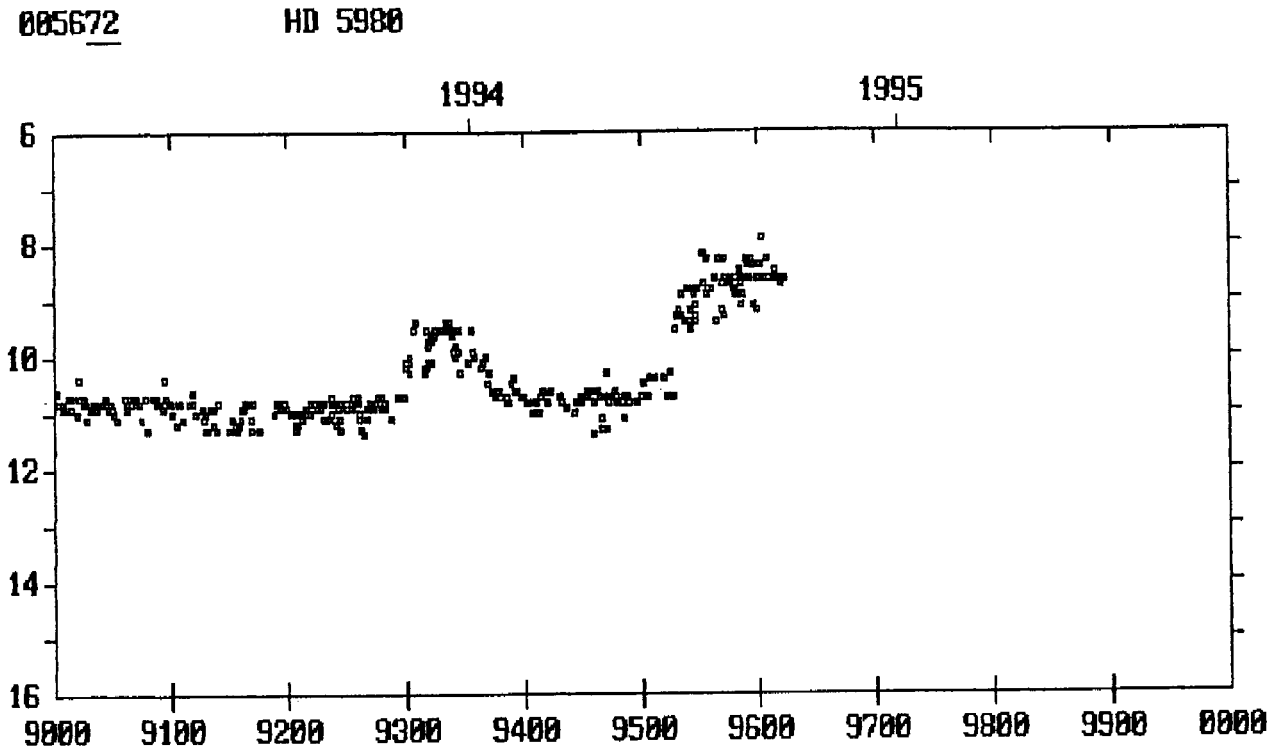




HD 5980

FIGURE 1

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,447,265 - J.D. 2,449,000




JD 2449000 - 2450000

FIGURE 2

HD 5980 LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS
J.D. 2,449,000 - J.D. 2,449,608

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# DO SOME DWARF NOVAE HAVE SHORT-LIVED FLARES OR PRECOURSERS TO OUTBURSTS? - PAPER 3.

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*SUMMARY: Details of three possible flares of TW Vir and one of TU Indi are reported.*

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## 1. INTRODUCTION

Previous papers (1:2) gave details of possible short-lived flares or precoursers to outbursts of dwarf novae. The first paper gave the strict criteria for determining flare activity in dwarf novae.

It is now accepted that flares occur in a wide range of variable stars, because they have been observed in a range of wave-lengths.

## 2. OBSERVATIONS

The outbursts of the dwarf nova TW Vir are discussed in a paper in this issue. The detailed examination of the visual observations showed several examples of possible flares. All except three were rejected because they did not conform to the stipulations laid down in Paper 1. The three remaining examples are listed below in the same format as in previous papers.

A possible flare in August 1994 was noted when processing the observations for that month. This is shown below.

POSSIBLE PRECOURSERS TO OUTBURSTS IN TWO DWARF NOVAE

| | OBSERVATION | | | Max | | PRECEDING OBS. | | | FOLLOWING OBS. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | J.D. 24 ..... | Magv | Obs | J.D. 24..... | Int d. | J.D. 24 ..... | Magv | Obs | J.D. 24 ..... | Mag | Obs |
| TW VIR | | | | | | | | | | | |
| 1 | 42,218.90 | 13.8 | Ty | 42,222 | 4 | 42,218.80 | <12.8 | Jo | 42,218.91 | <13.1 | Jn |
| 2 | 45,370.13 | 13.0 | Jo | 45,378 | 8 | 45,362.17 | <12.8 | Jo | 45,370.4 | <13.7 | Hz |
| 3 | 46,223.75 | 13.6 | Aj | 46,229 | 6 | 46,223.2 | <13.6 | Ov | 46,223.98 | <13.8 | Hl |
| TU INDI | | | | | | | | | | | |
| 1 | 49,567.943 | 13.3 | HA | 49,579 | 11 | 49,567.5 | <13.5 | Ov | 49,568.0 | <13.8 | Ty |

## 3. DISCUSSION

The three flares of TW Vir appear to be precoursers to outbursts which occurred 4, 8, & 6 days after the flares. The flares are faint which is natural as outbursts of TW Vir are not very bright and the flares show a tendency to occur only prior to the brightest outbursts.

The flare in TU Indi preceded an outburst by 11 days and appears to be definite. The outburst cycle of TU Indi is much longer than that of TW Vir.

## REFERENCES

(1) Bateson, F.M. 1991. Publ. 16. Var.Star Section. R.astr. Soc. of N.Z. pp 75-80.

(2) Bateson, F.M. 1991. Publ. 17. Var.Star Section. R.astr. Soc. of N.Z. pp 74-75.

# LIGHT CURVES OF SOME MIRA VARIABLES

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SUMMARY: *Decades of observations are reproduced as computer light curves for the Mira variables - R Oct; R Col; RW Car & S Col.*

. . . . . .

## 1. INTRODUCTION

Our previous paper (1) gave details of the origin of the V.S.S. and its programmes.

## 2. OBSERVATIONS

The light curves of four Mira variables on the following pages are the result of individual estimates made using the standard sequences. Observation of these stars commenced in the 1920's or early 1930's. Estimates in the first decade were less frequent than in subsequent years and the earlier curves are not reproduced although they provide valuable data on the stars concerned.

The main objective in publishing the light curves in advance of a discussion on each variable is to encourage observers to continue observing them and at the same time let them see the results of their observations.

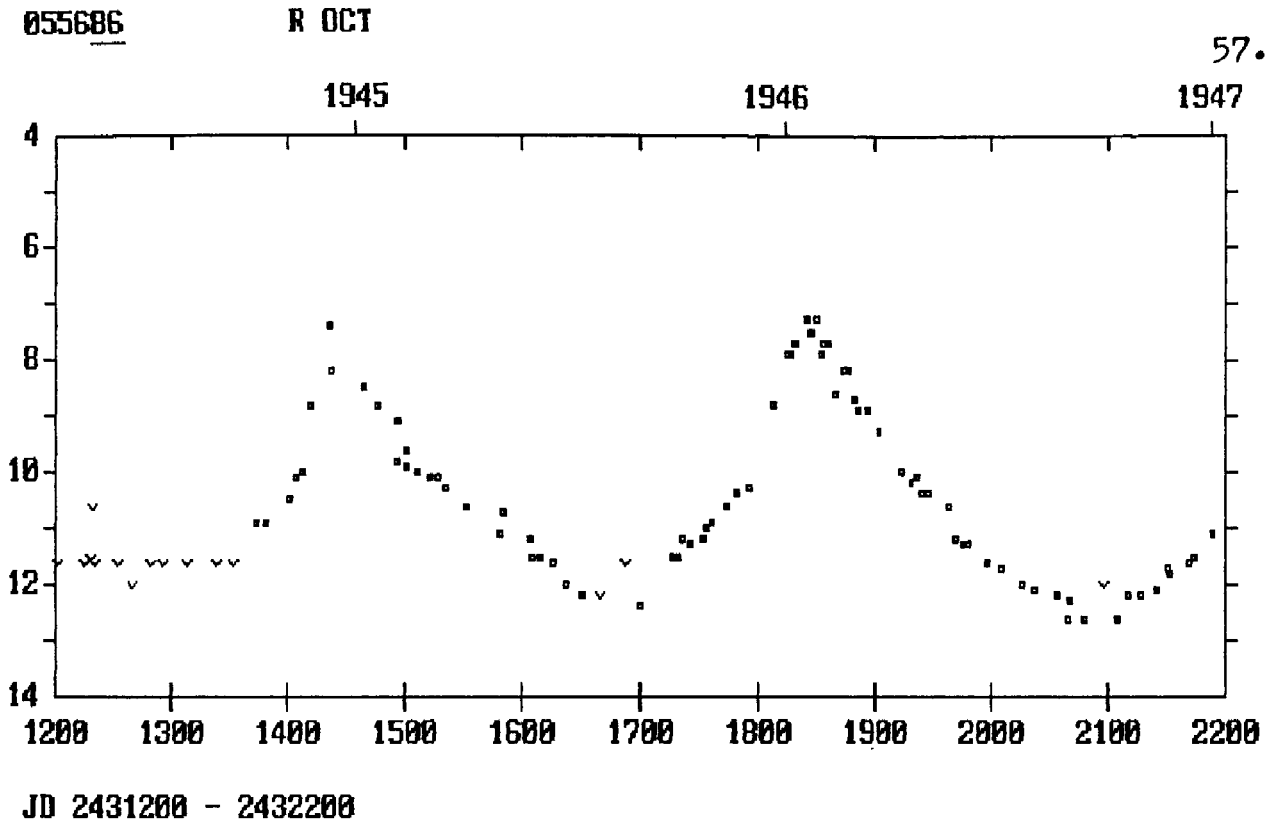
The range of these variables are entirely within the thresholds used by most members. T and S Col are in proximity to the sun at certain seasons and morning observations are required as soon as possible when the stars emerge into the morning sky. R Oct and RW Car can be observed the year round and, owing to their southerly declination their variations are best studied from our latitudes.

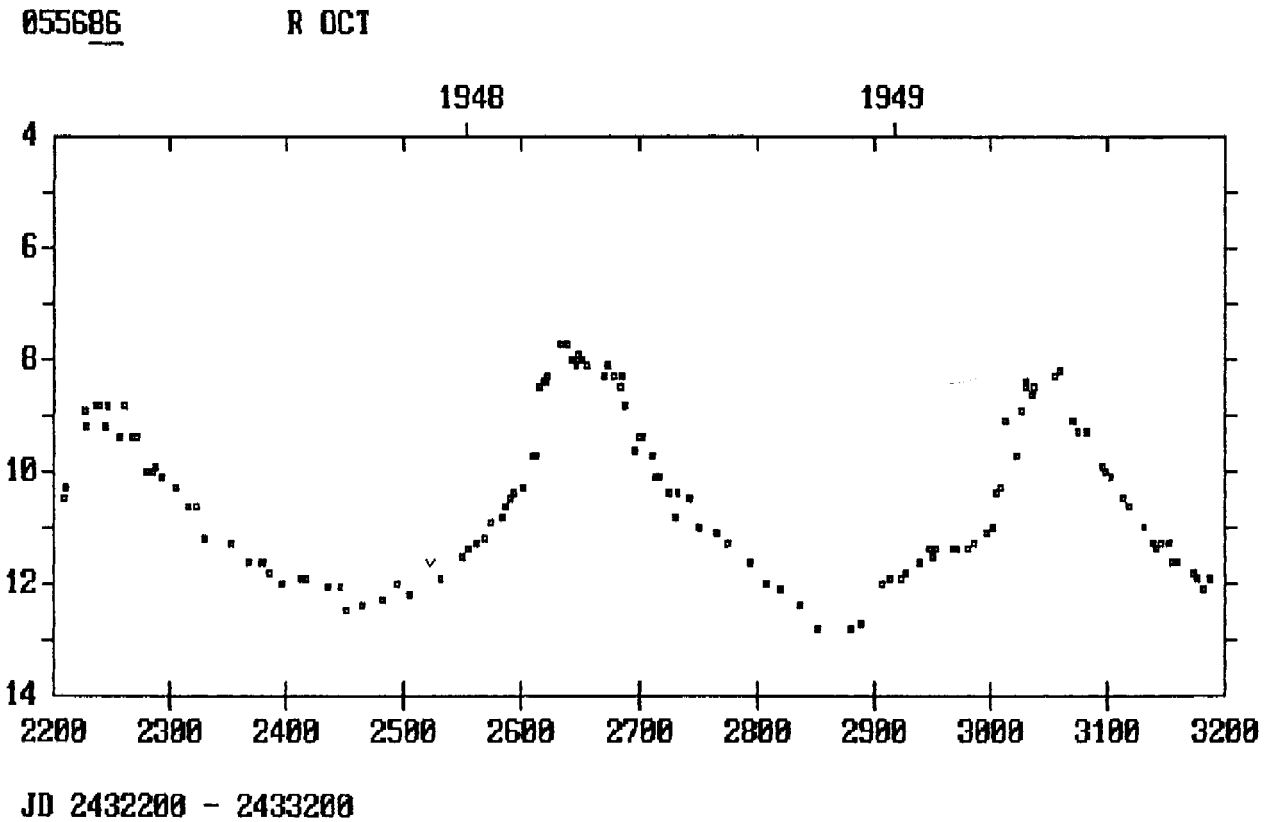
Observations of minima of RW Car are particularly required.

## REFERENCE

(1) McIntosh, R. & Brunt, D. 1992. Publ. Var. Star Section R.astr. Soc. N.Z. 18, p.45.

. . . . . .



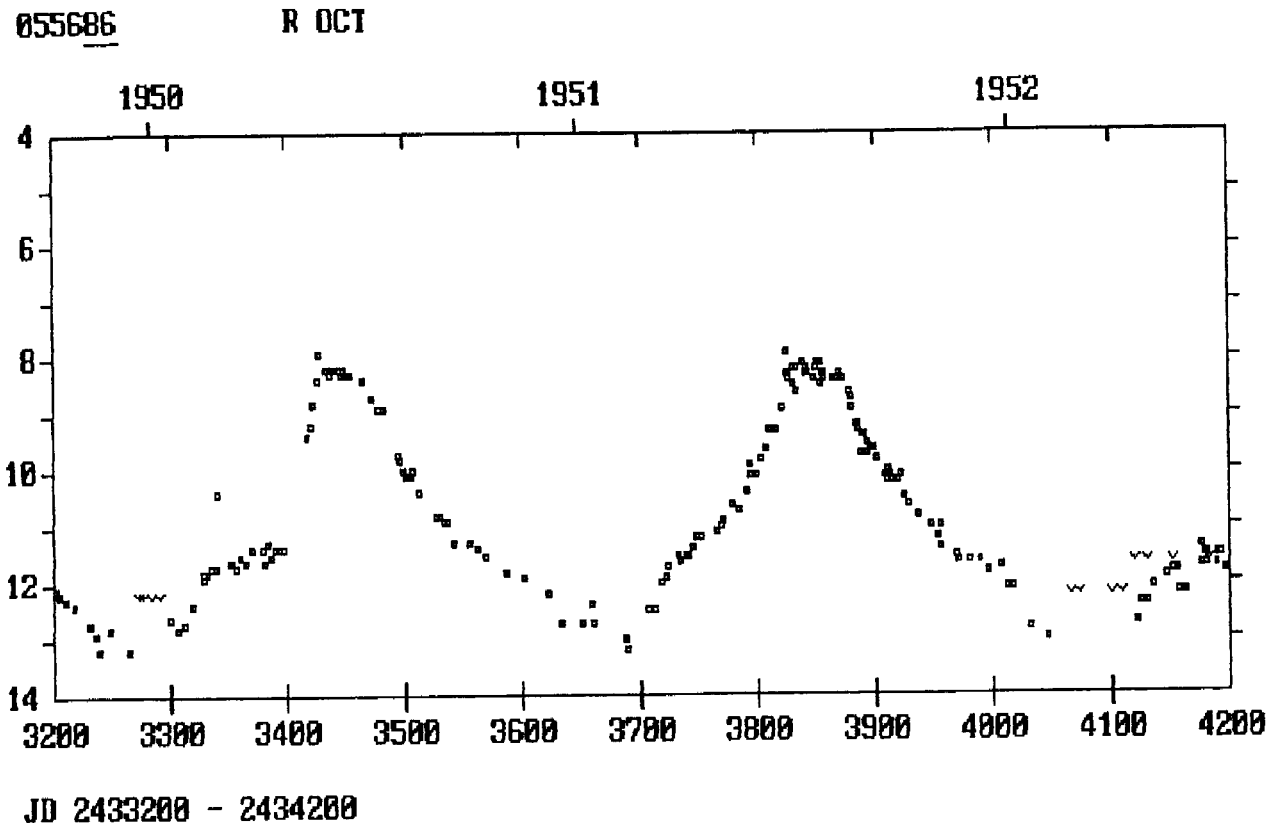



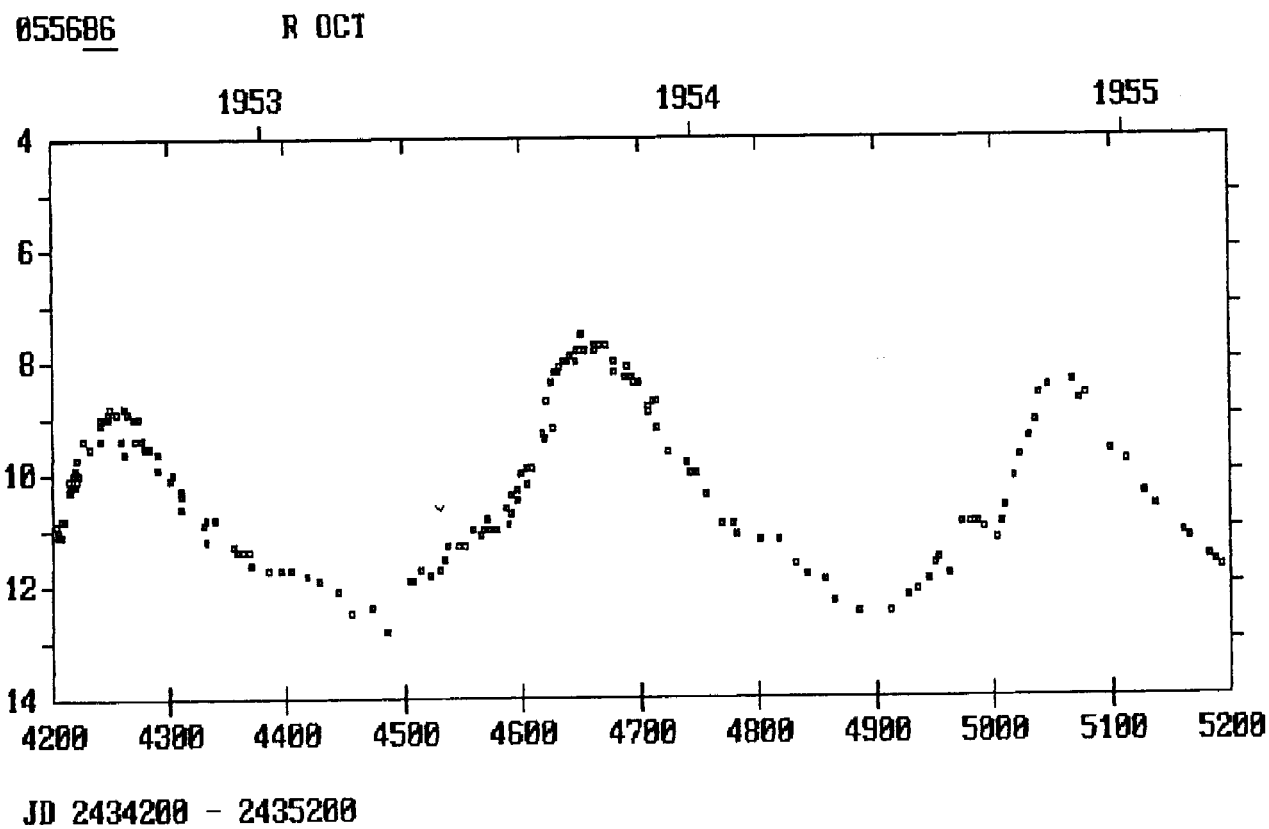

R OCT

FIGURE 1

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,431,200 - J.D. 2,433,200



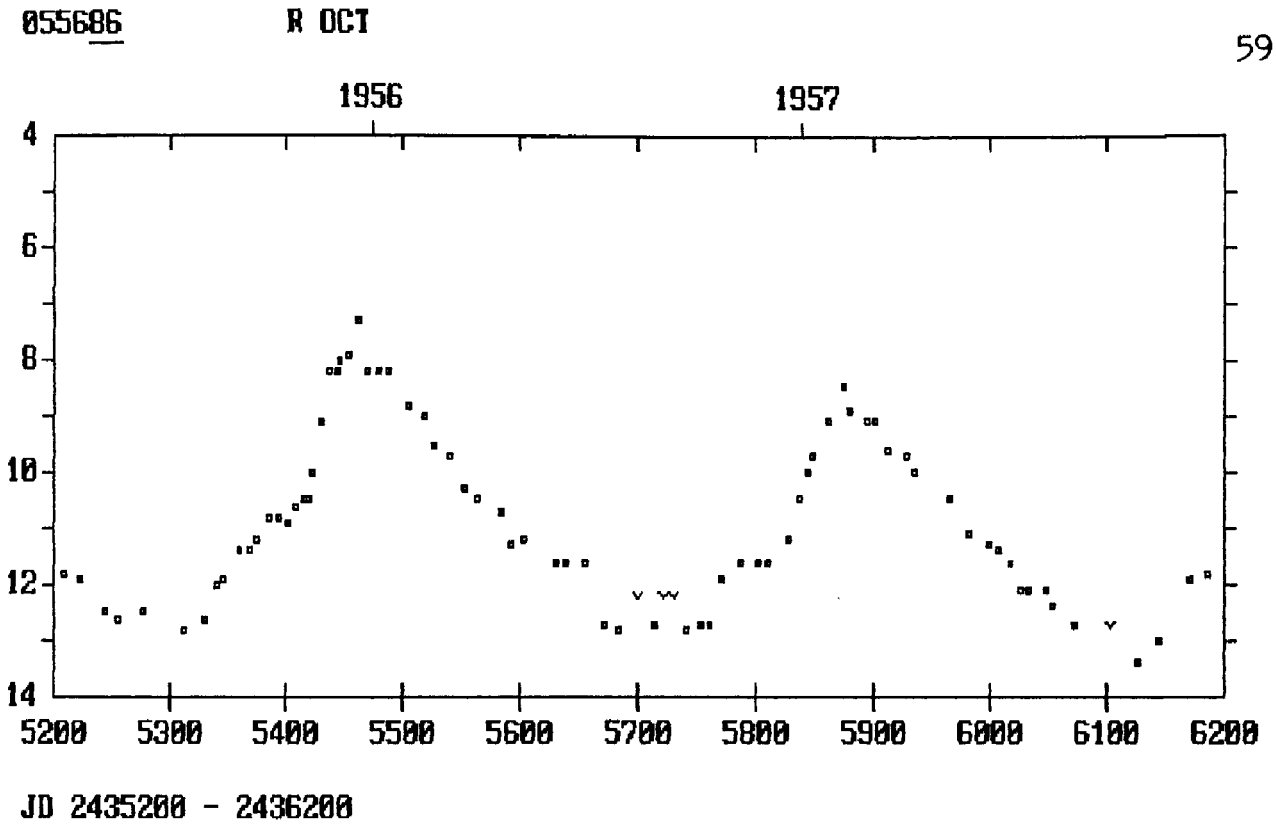



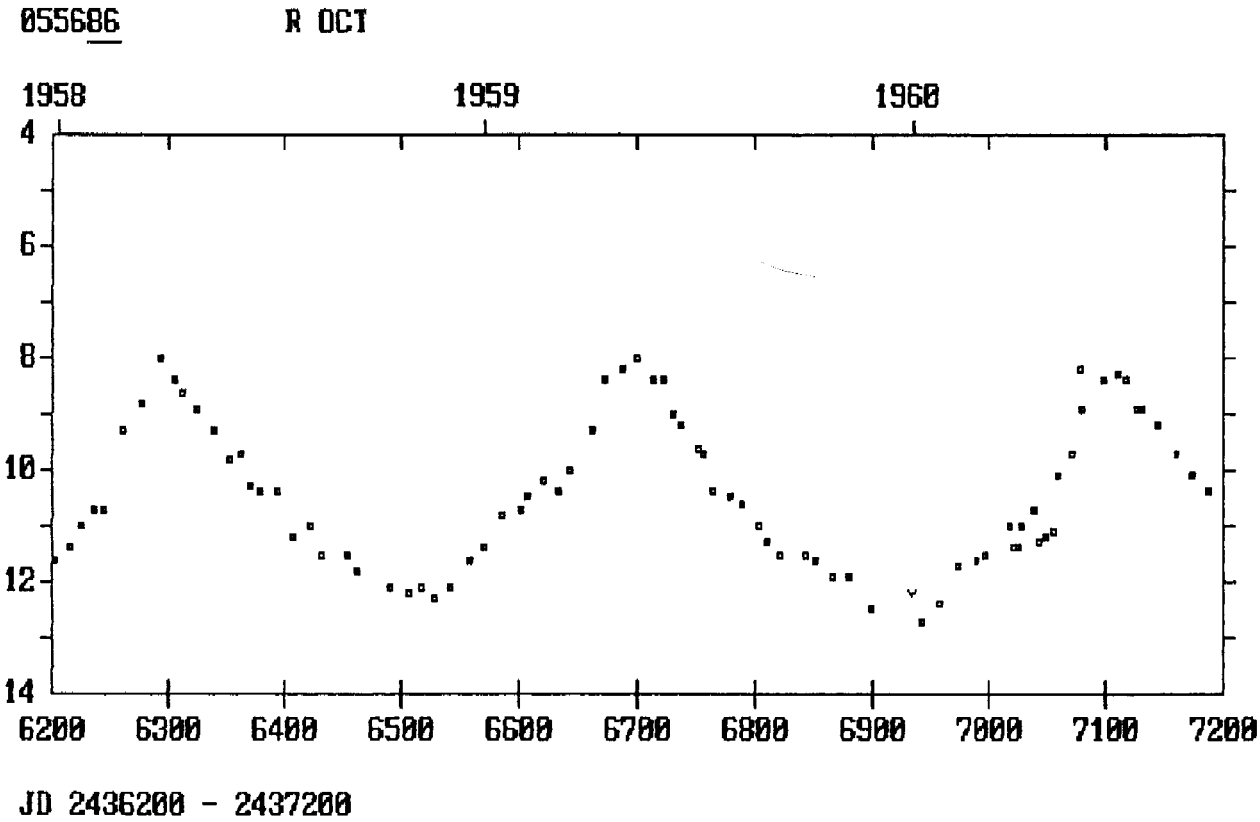

R OCT

FIGURE 2

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,433,200 - J.D. 2,435,200



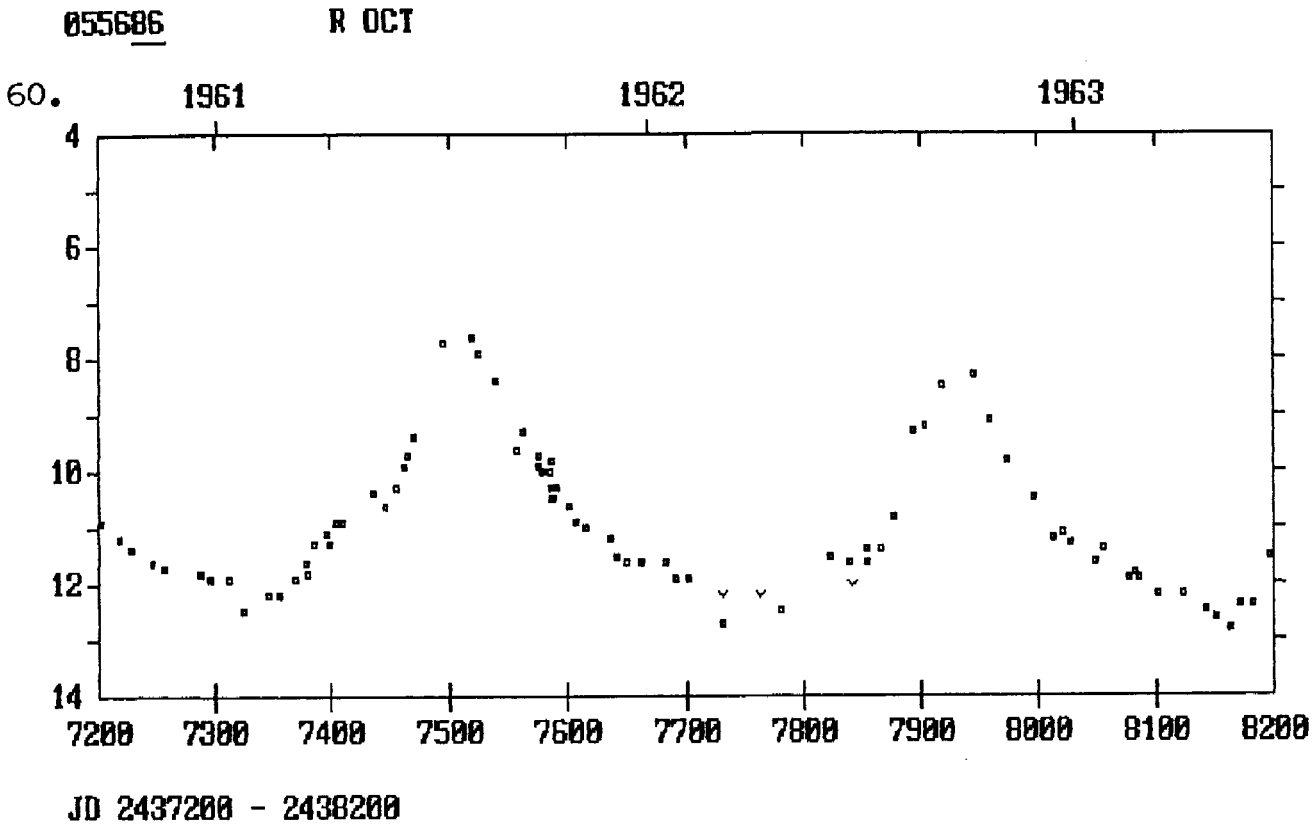



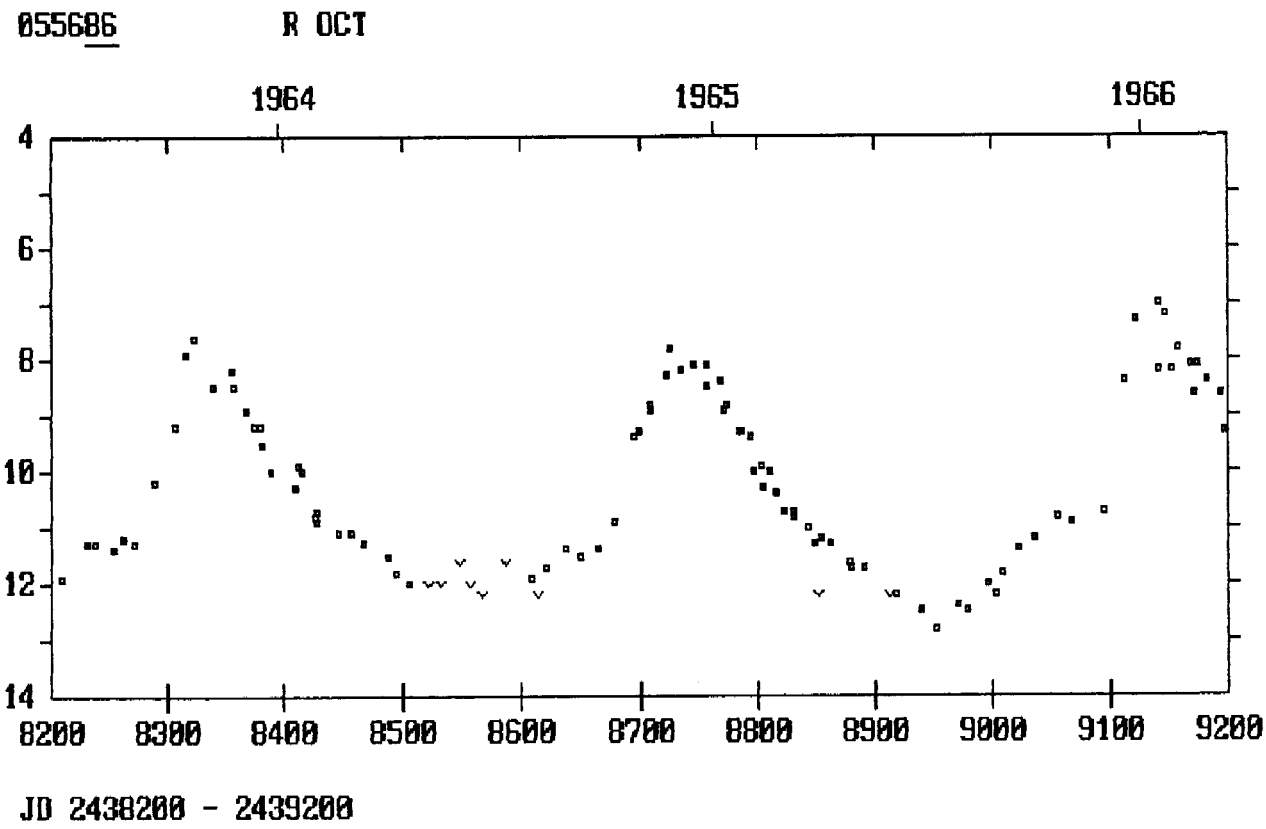

R OCT

FIGURE 3

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,435,200 - J.D. 2,437,200



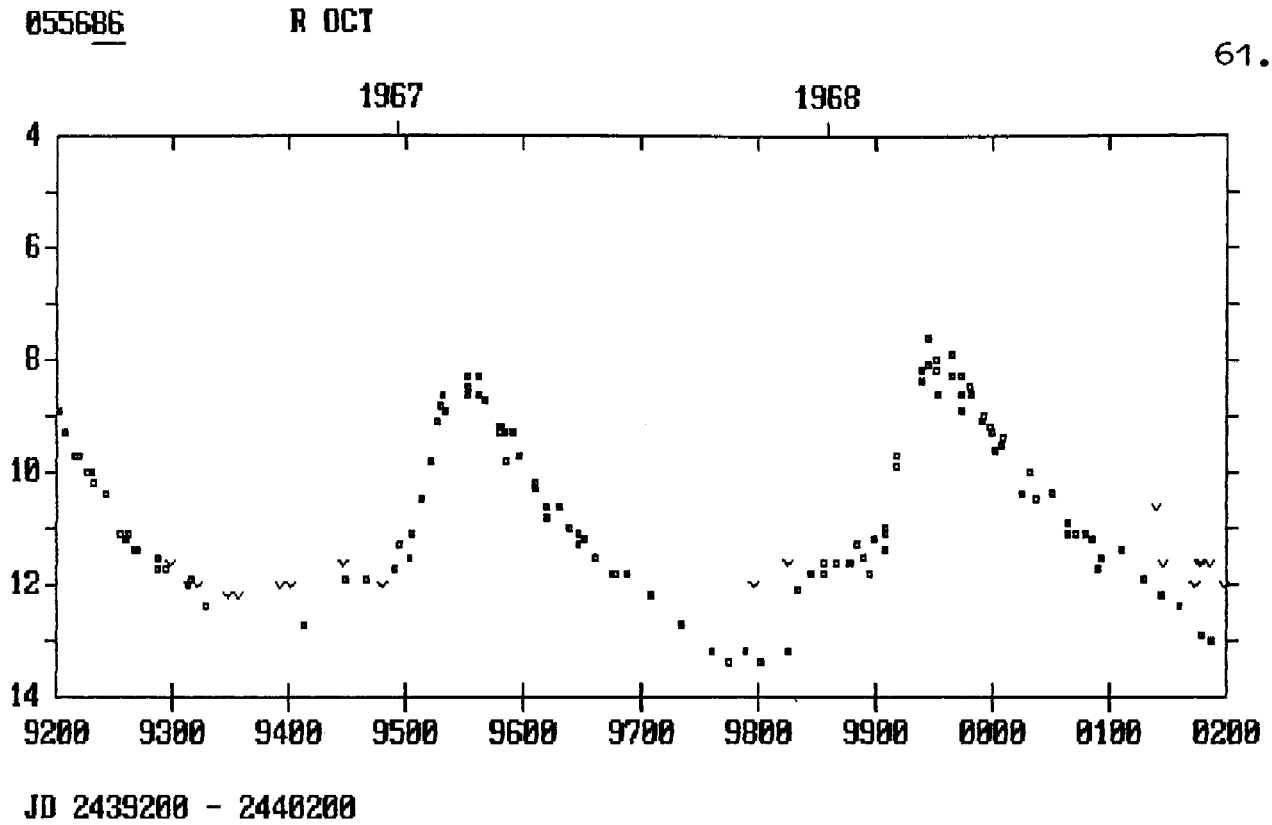



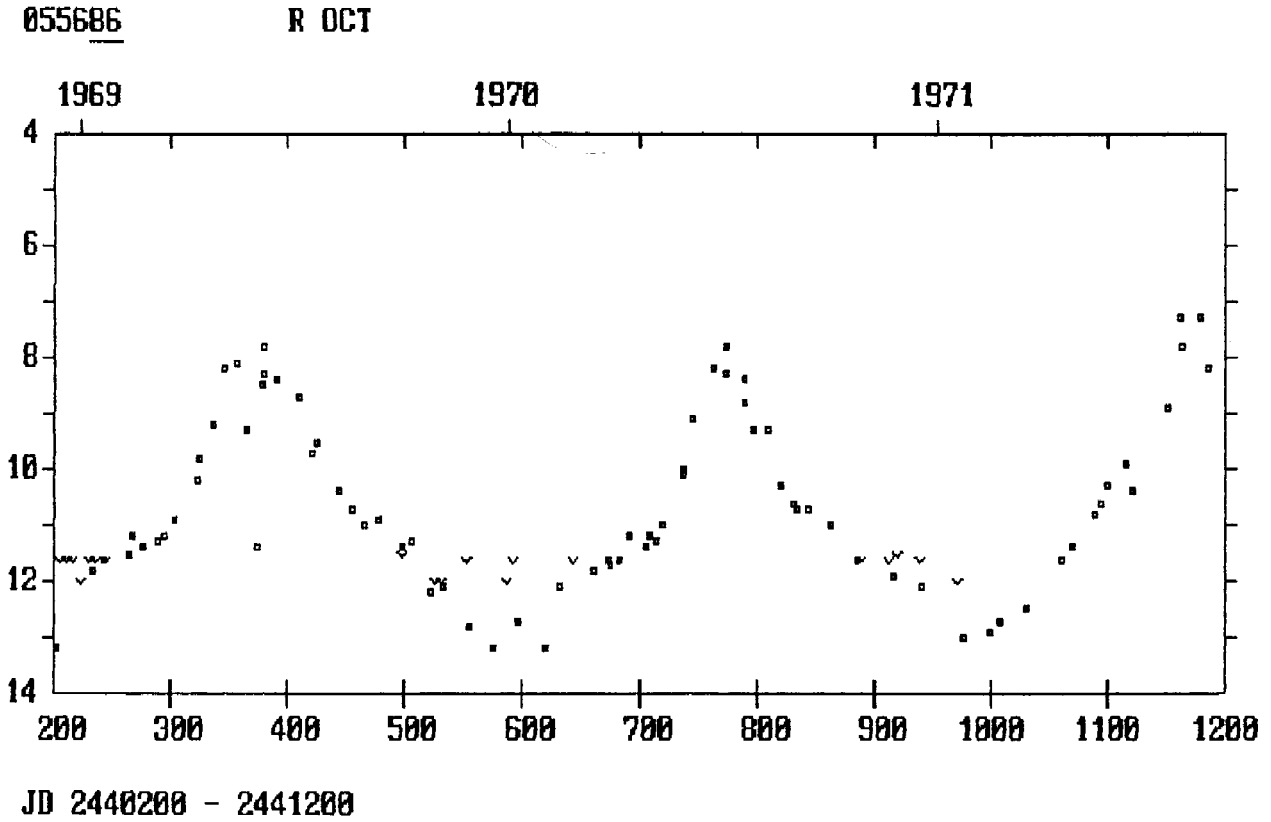

R OCT

FIGURE 4

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,437,200 - J.D. 2,439,200



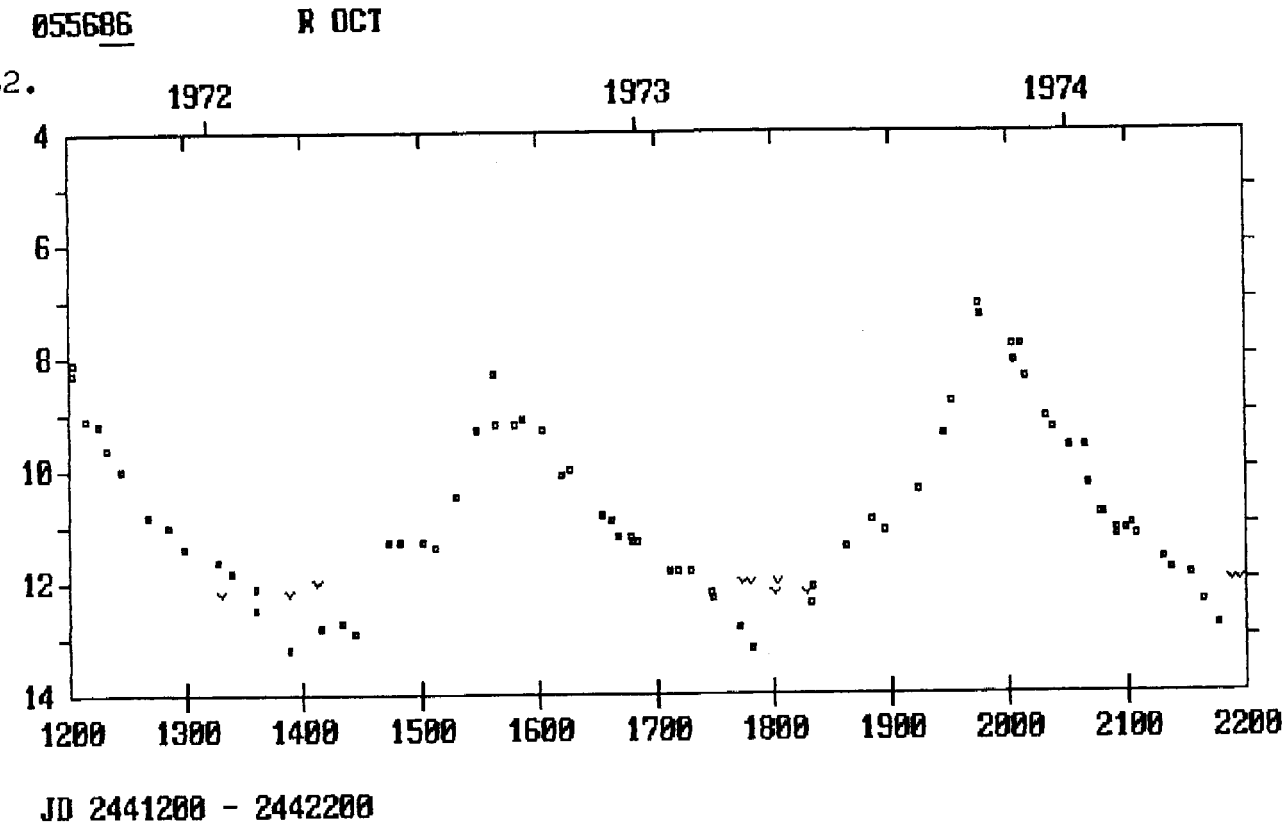



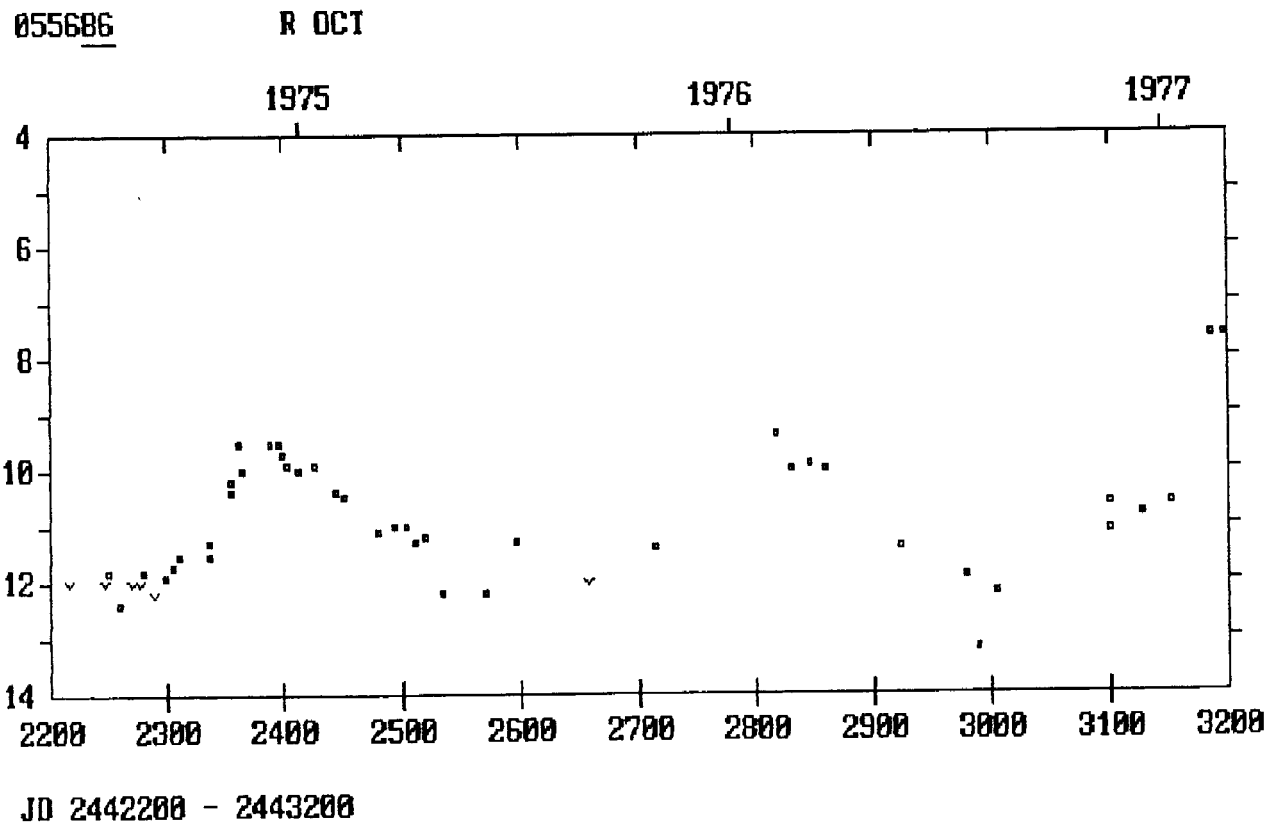

R OCT

FIGURE 5

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,439,200 - J.D. 2,441,200



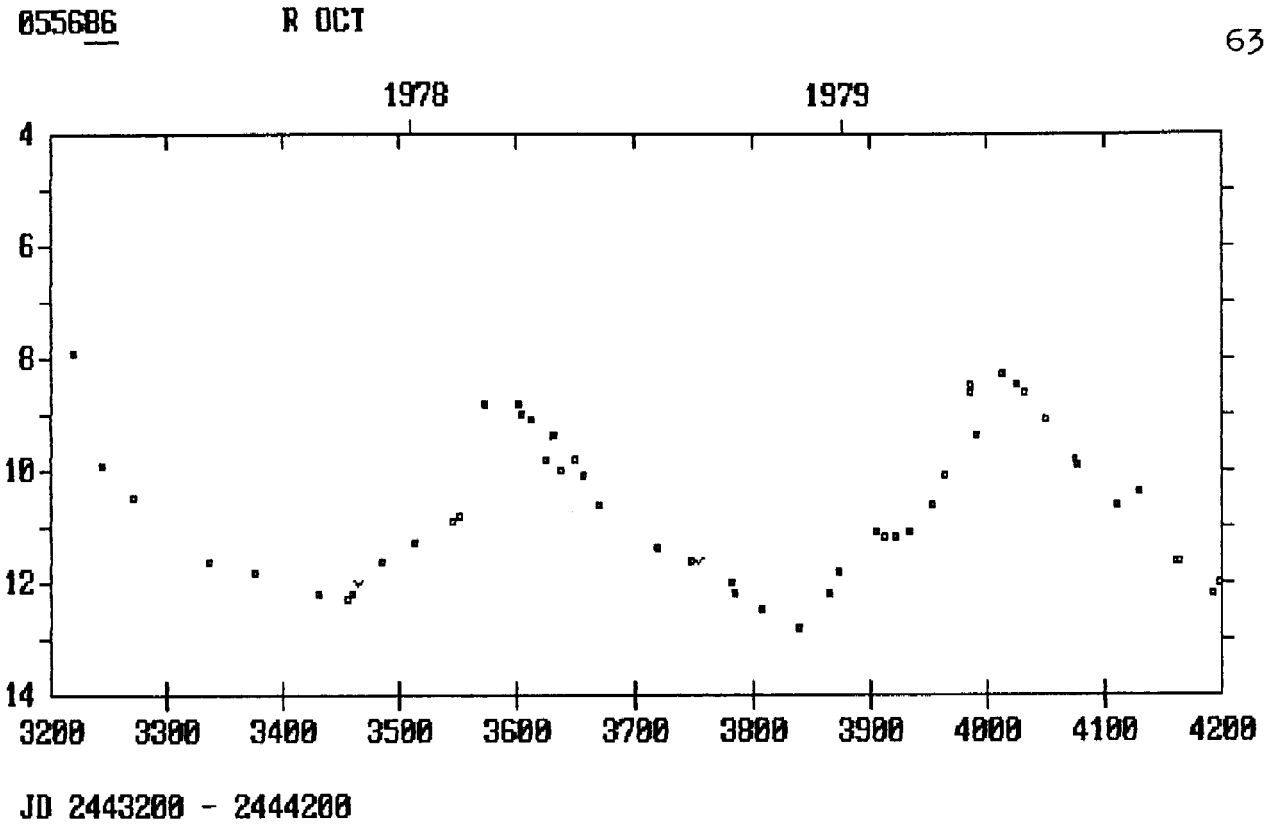



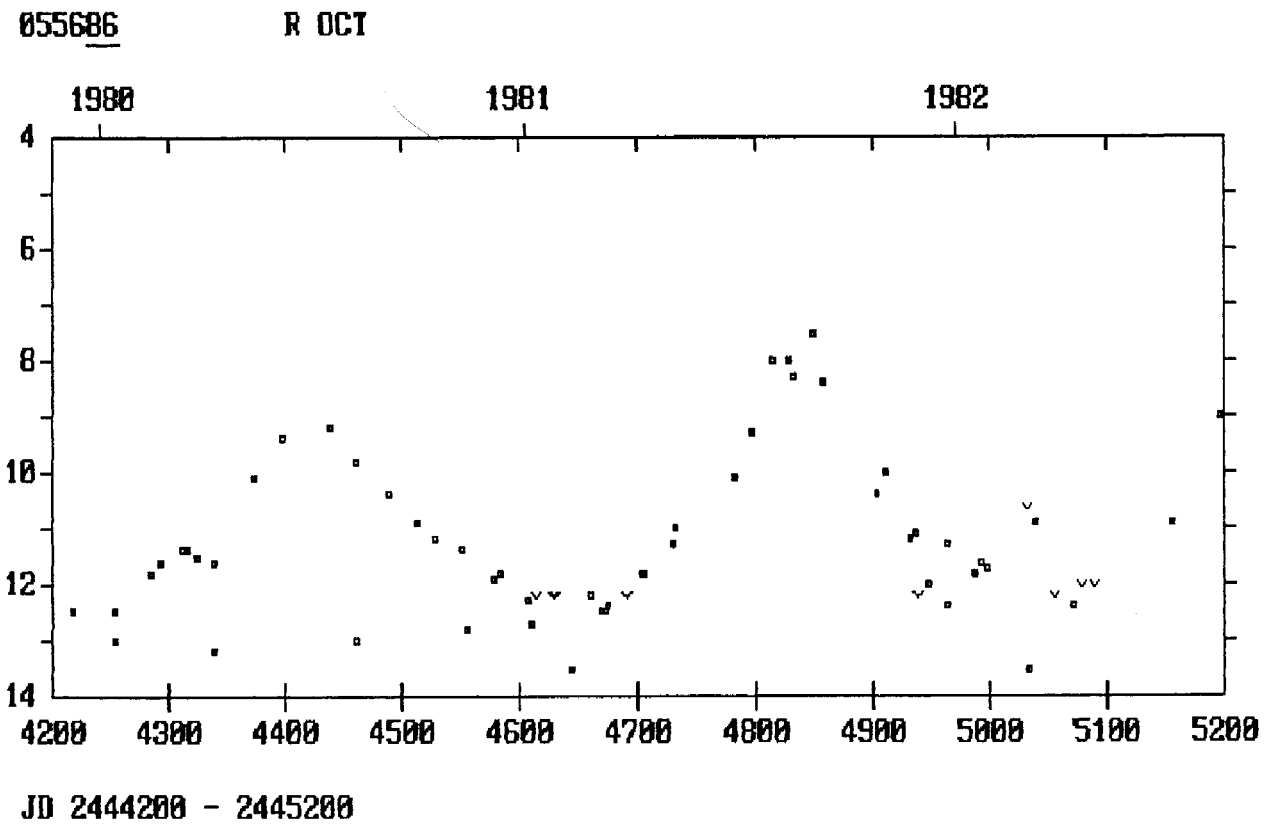

R OCT

FIGURE 6

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,441,200 - J.D. 2,443,200



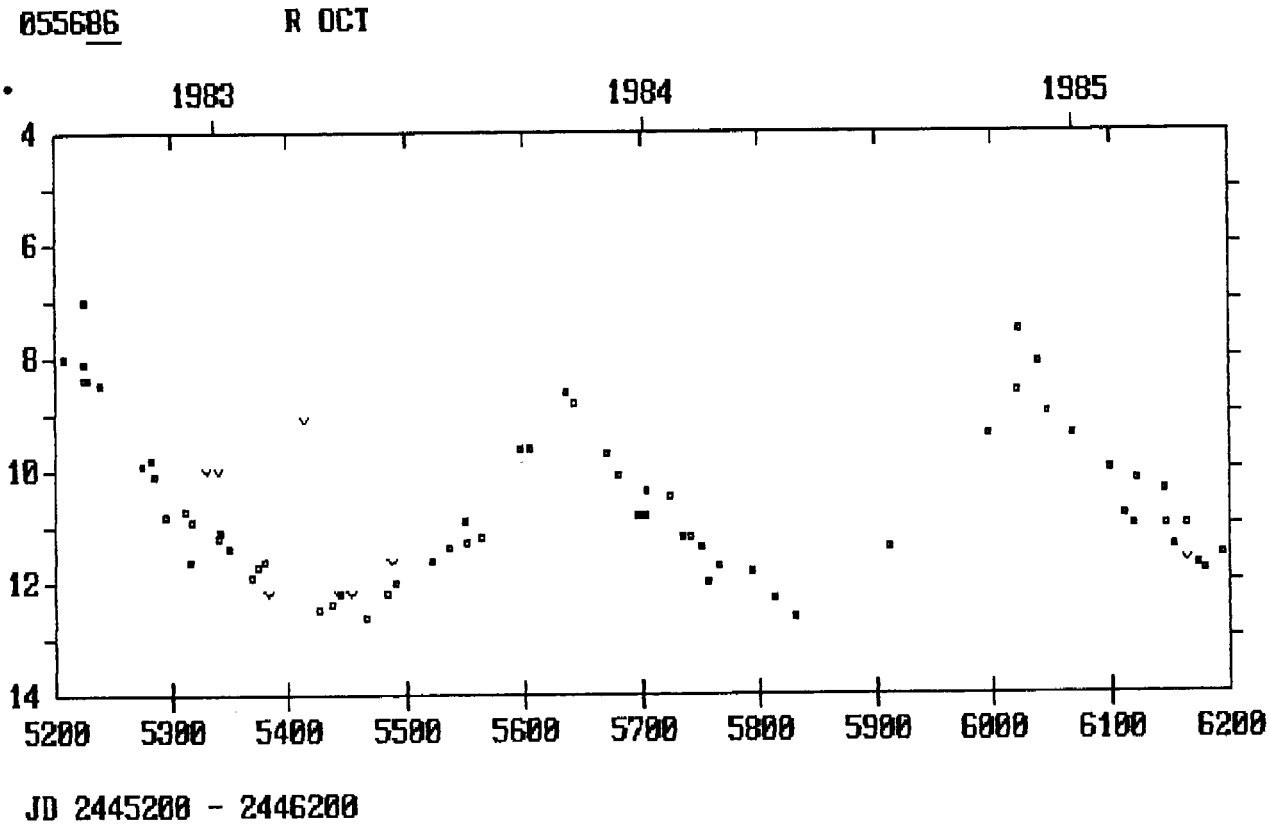



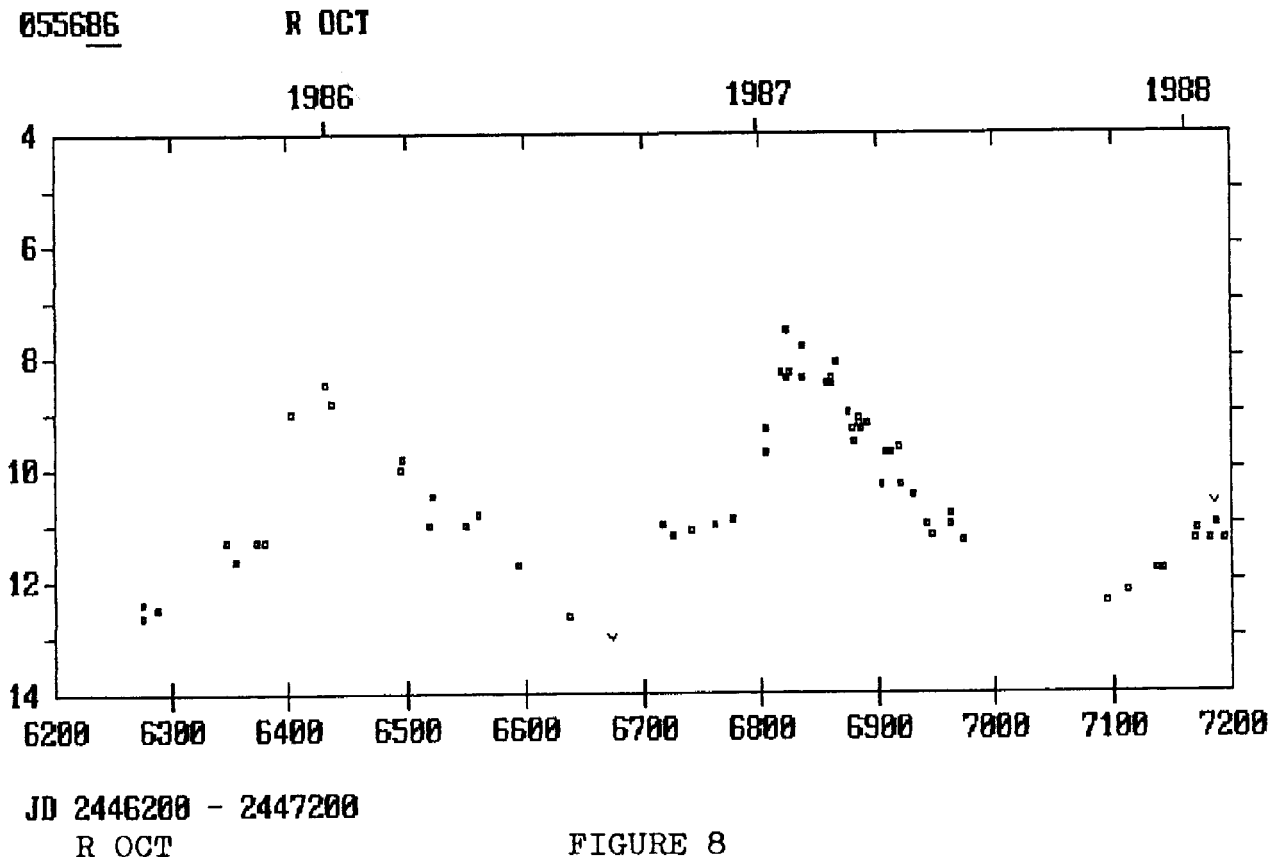

R OCT

FIGURE 7

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,443,200 - J.D. 2,445,200



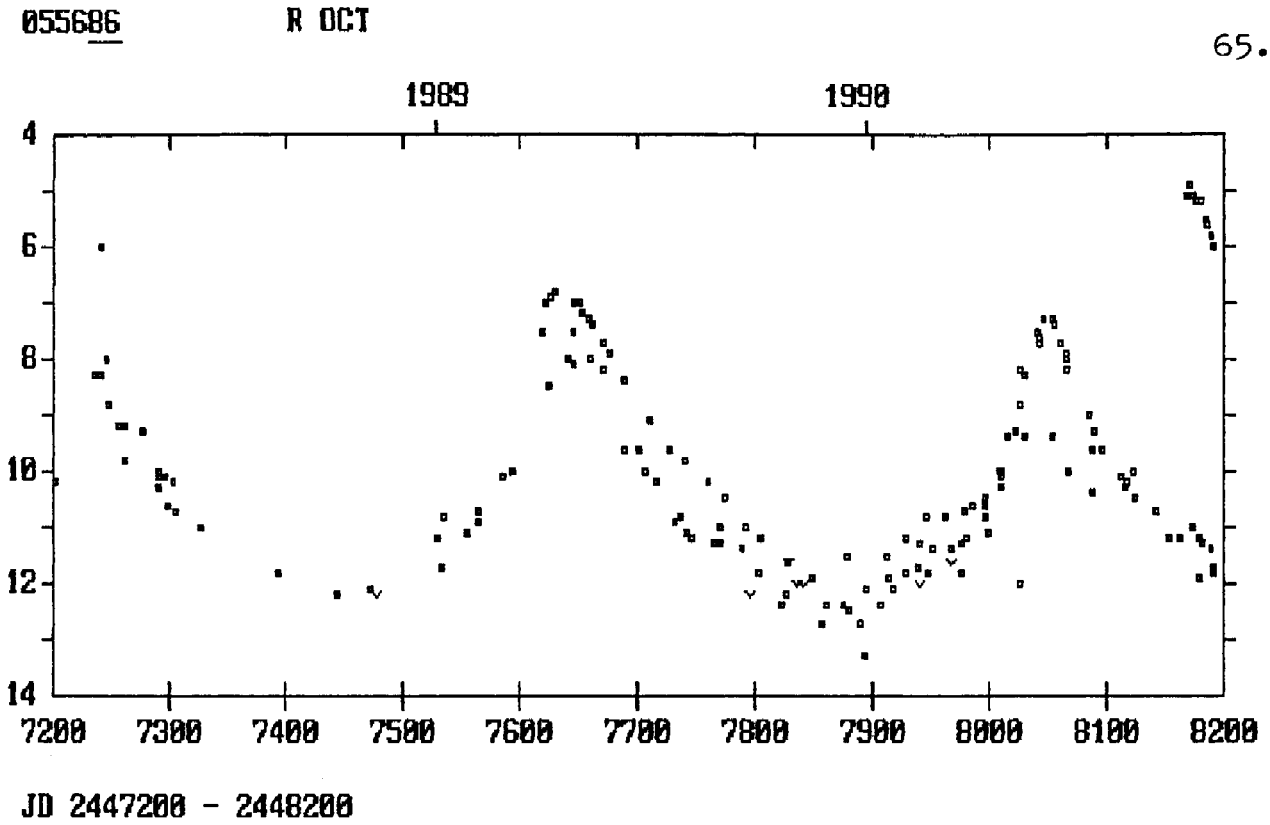



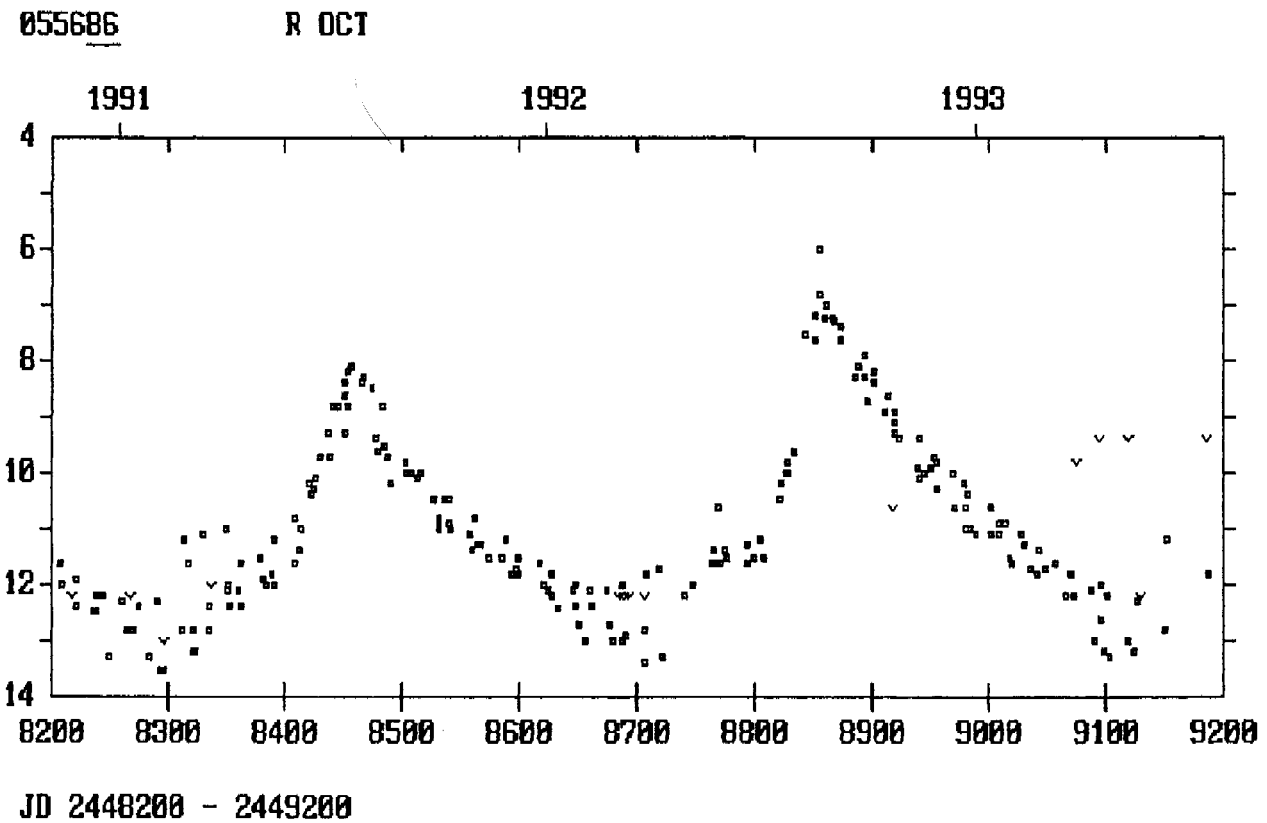

R OCT

FIGURE 8

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,445,200 - J.D. 2,447,200



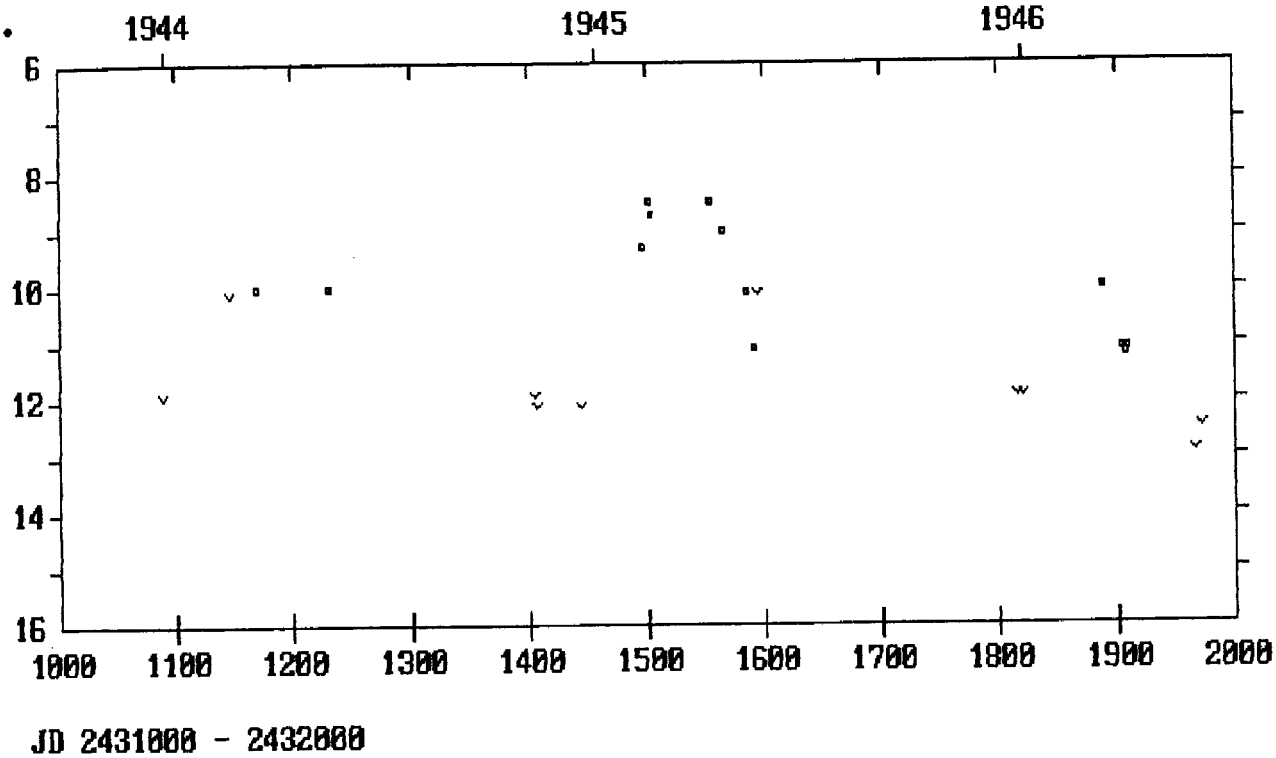



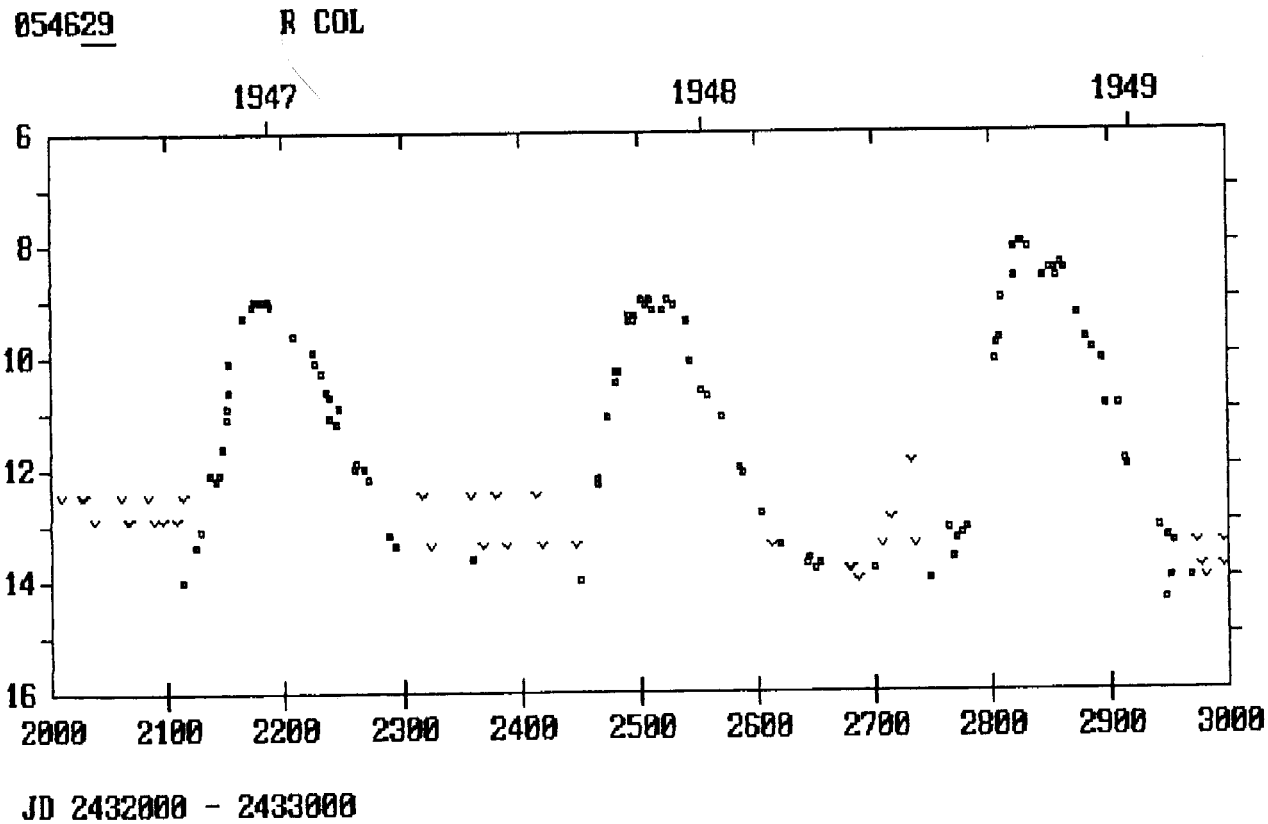

R OCT

FIGURE 9

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,447,200 - J.D. 2,449,200

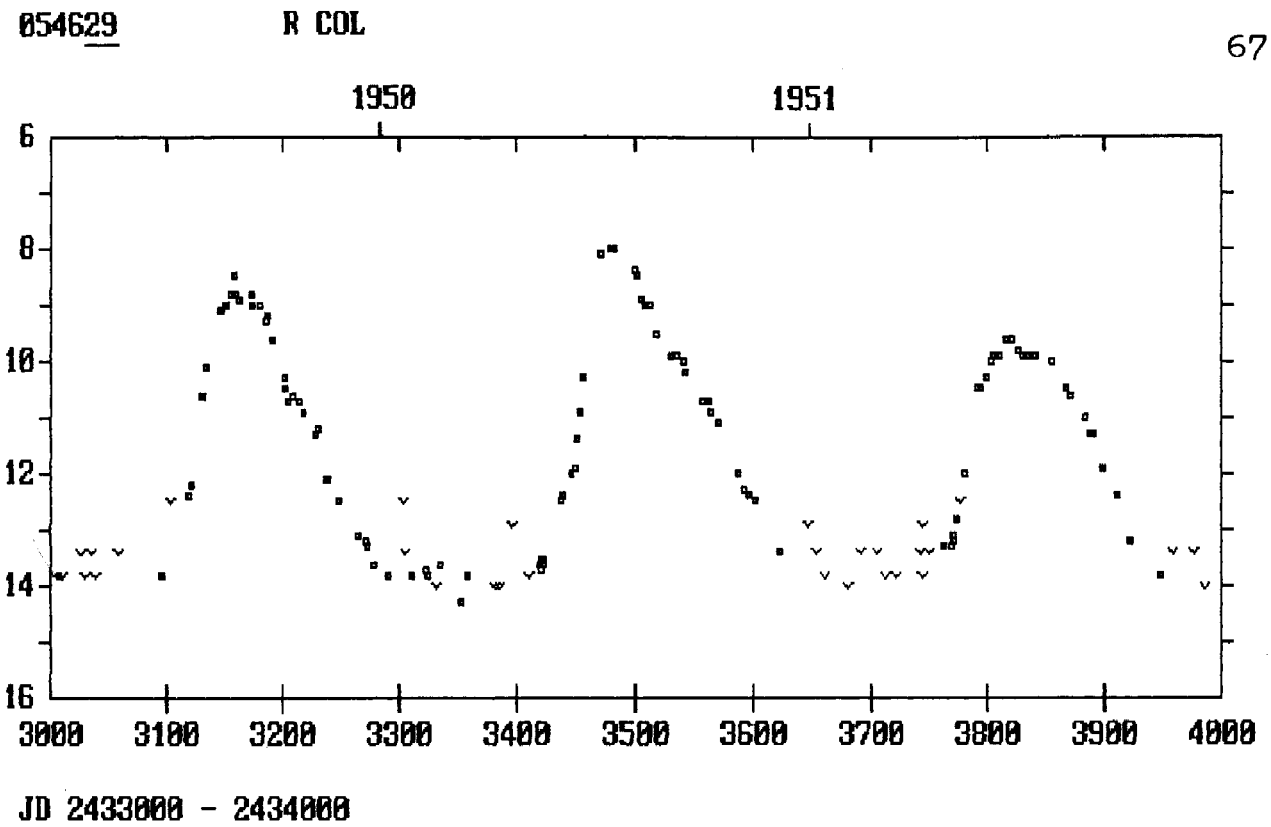


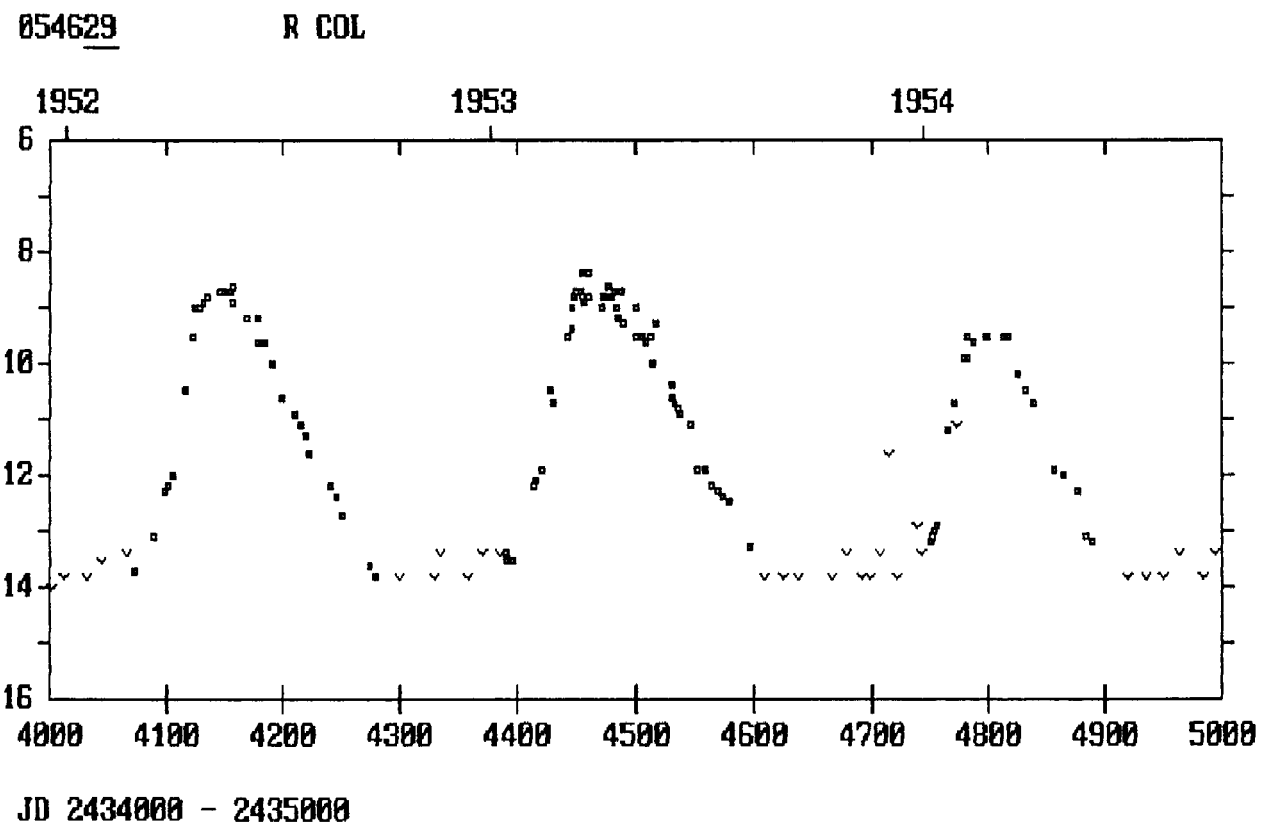




R COL

FIGURE 1

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS
J.D. 2,431,000 - J.D. 2,433,000



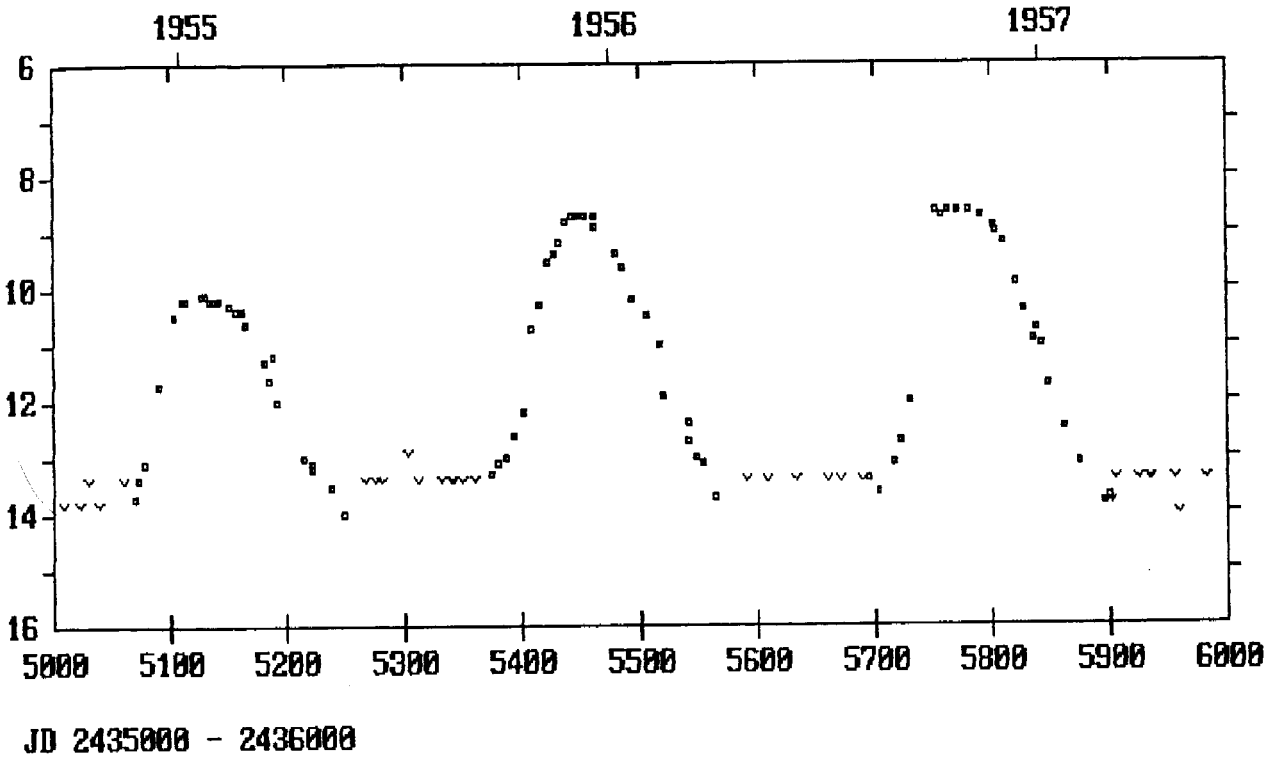



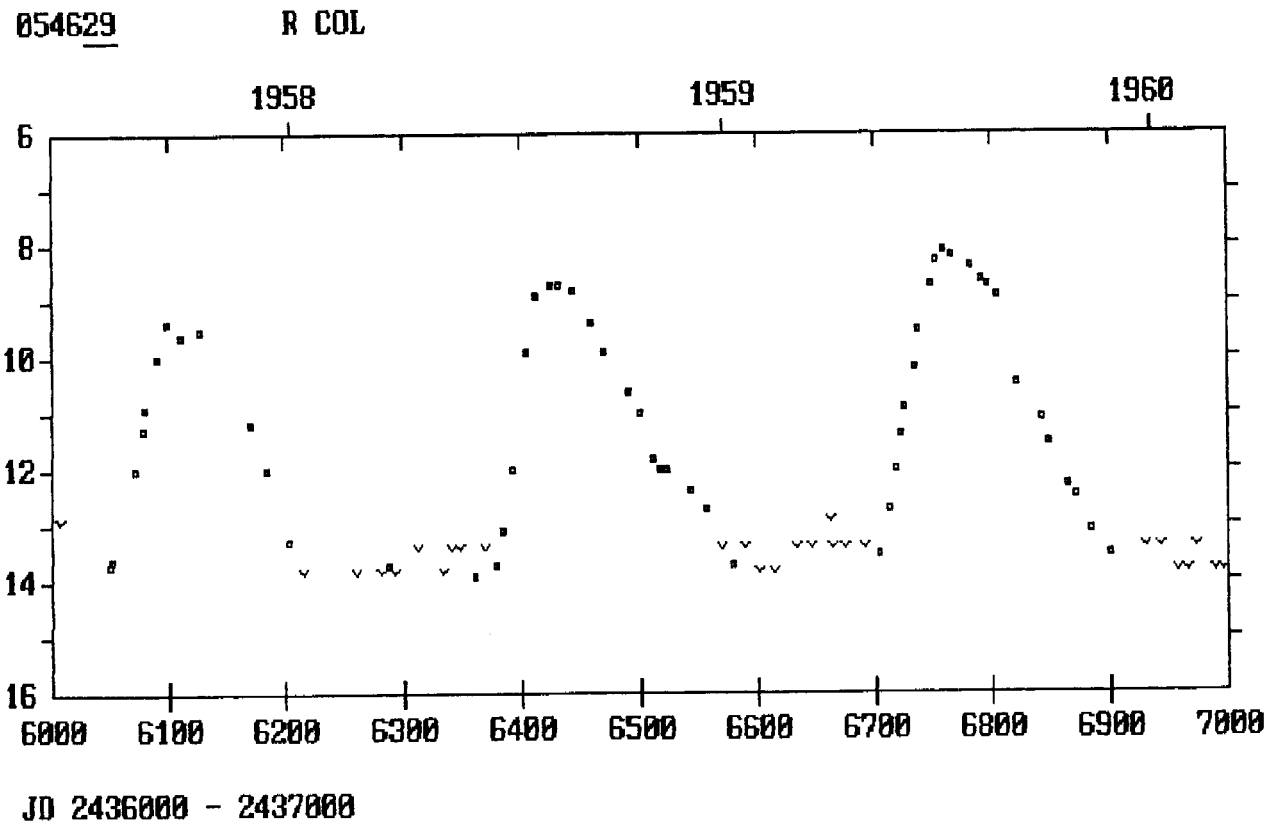

R COL

FIGURE 2

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,433,000 - J.D. 2,435,000



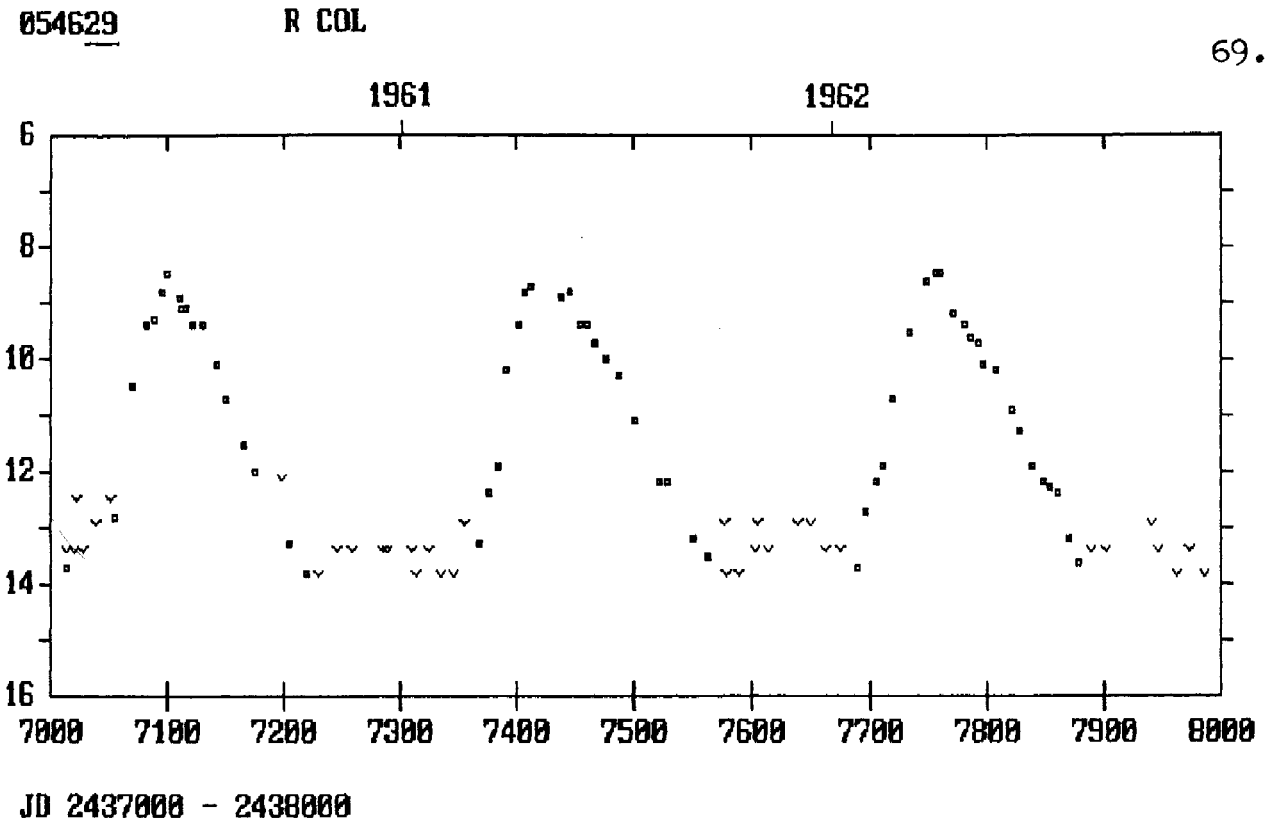



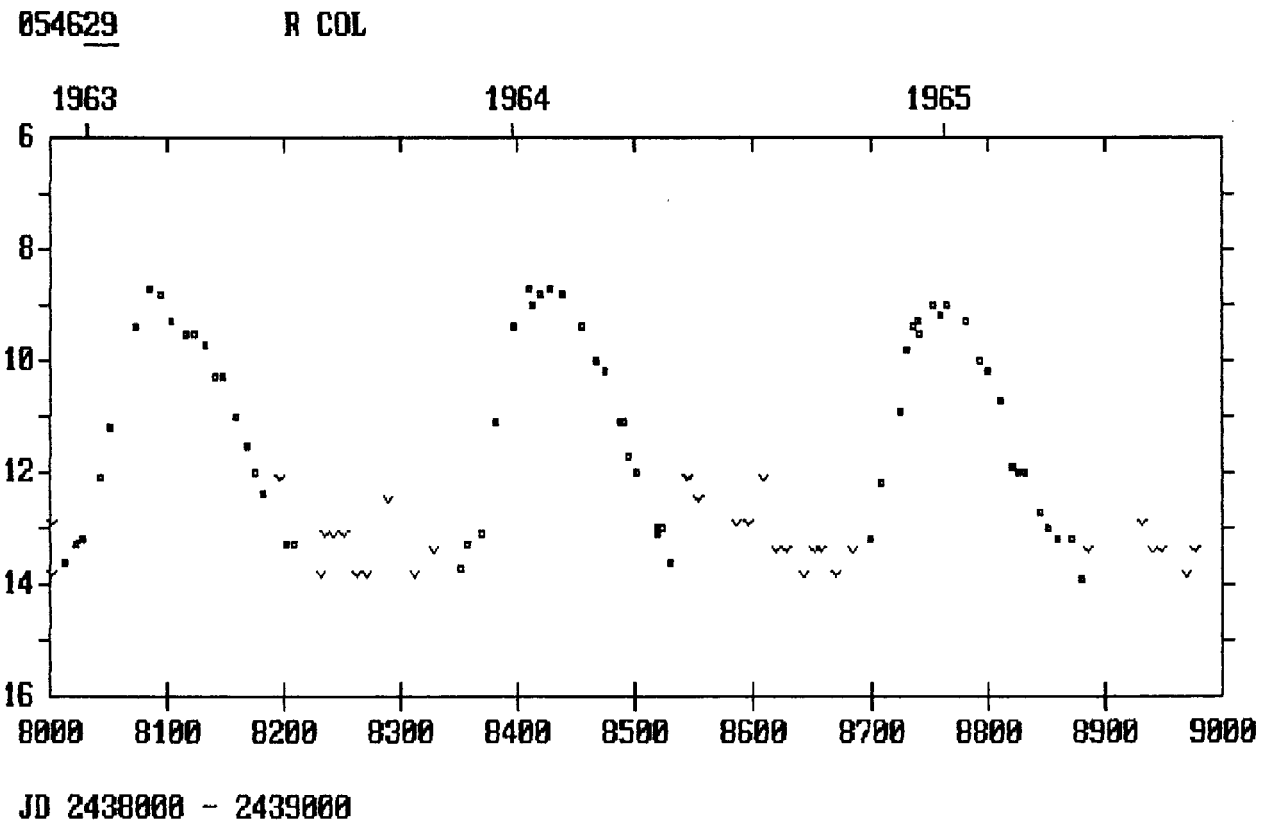

R COL

FIGURE 3

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

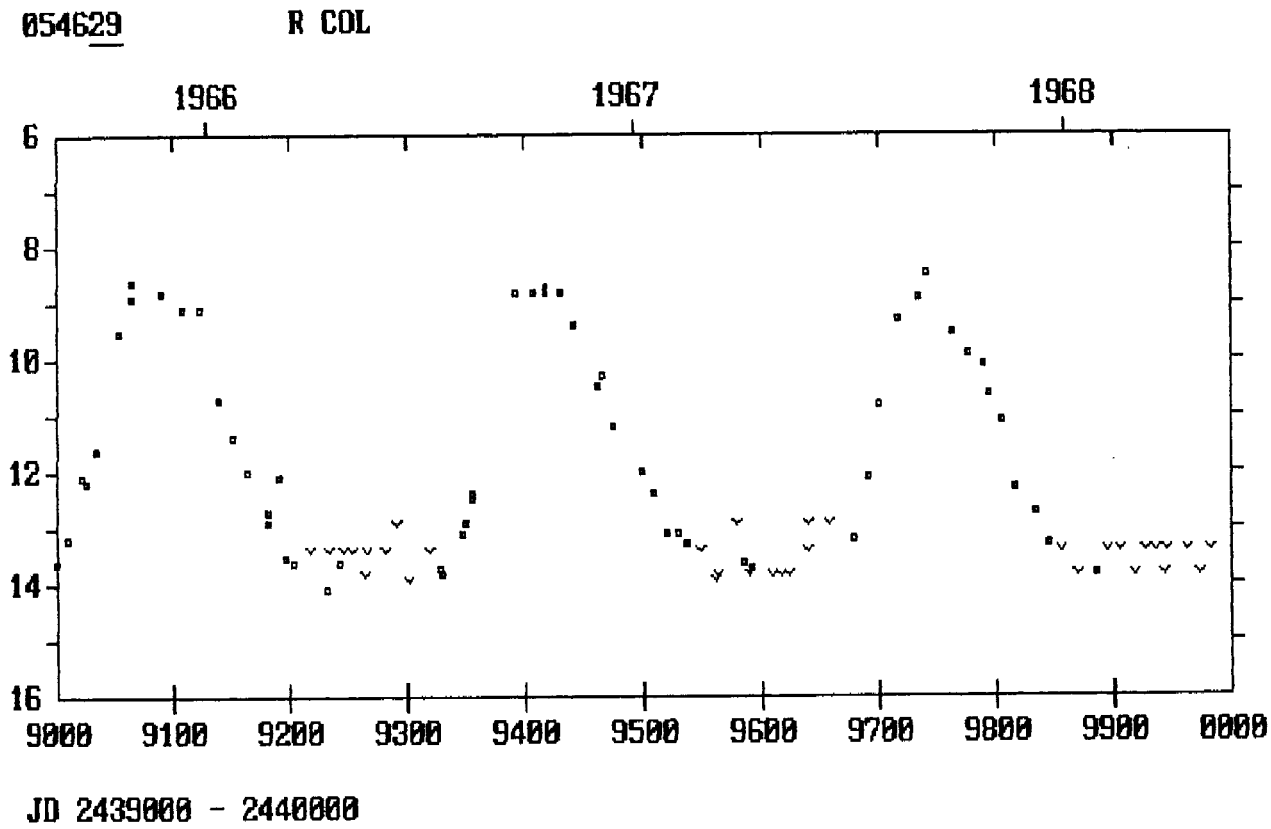
J.D. 2,435,000 - J.D. 2,437,000

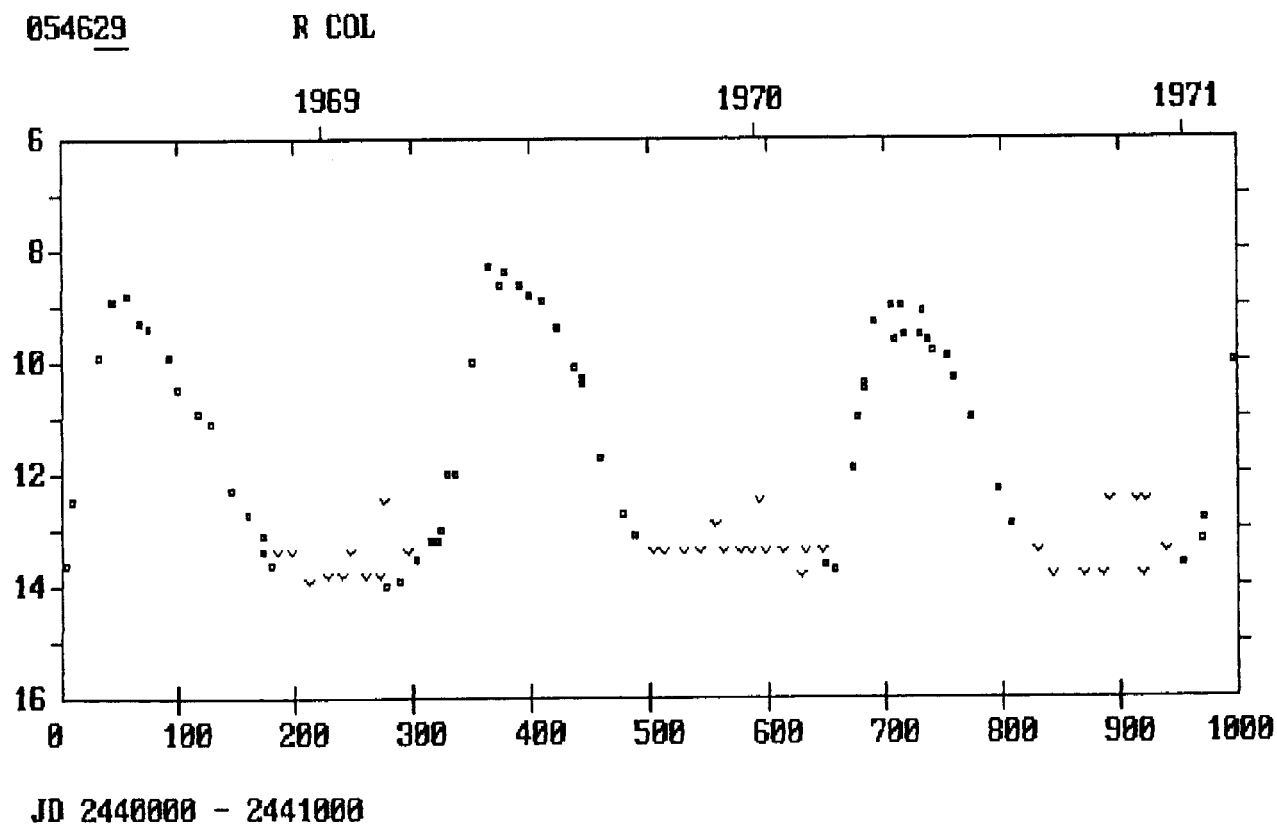



R COL FIGURE 4

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS
J.D. 2,437,000 - J.D. 2,439,000



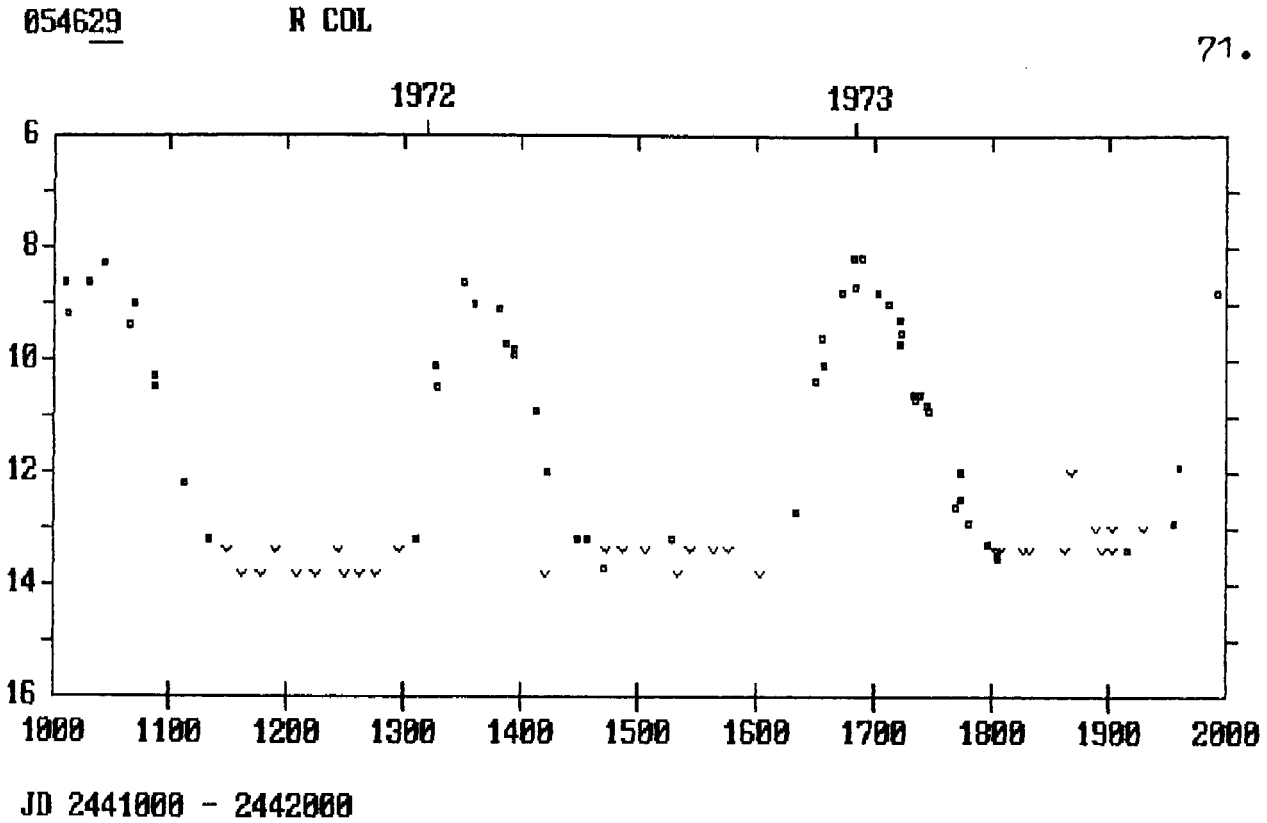



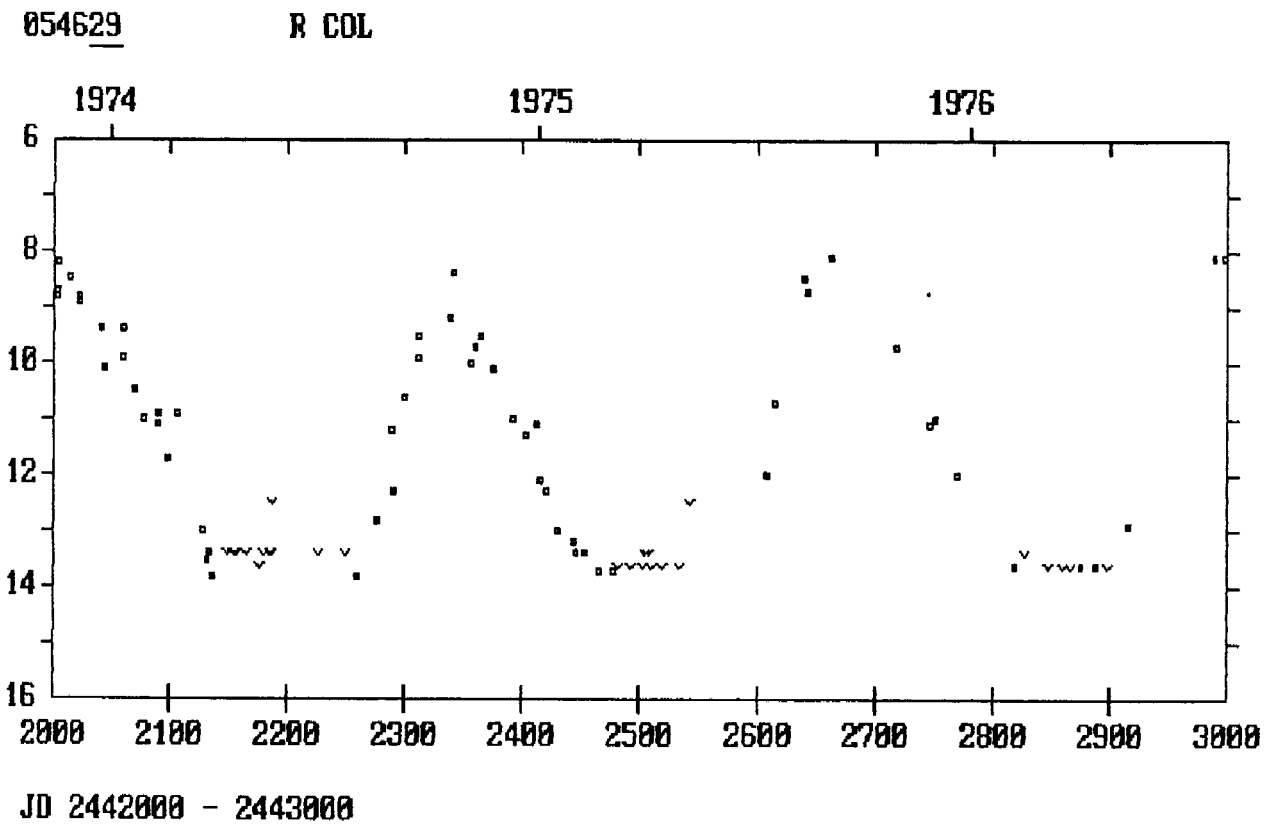

R COL

FIGURE 5

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,439,000 - J.D. 2,441,000



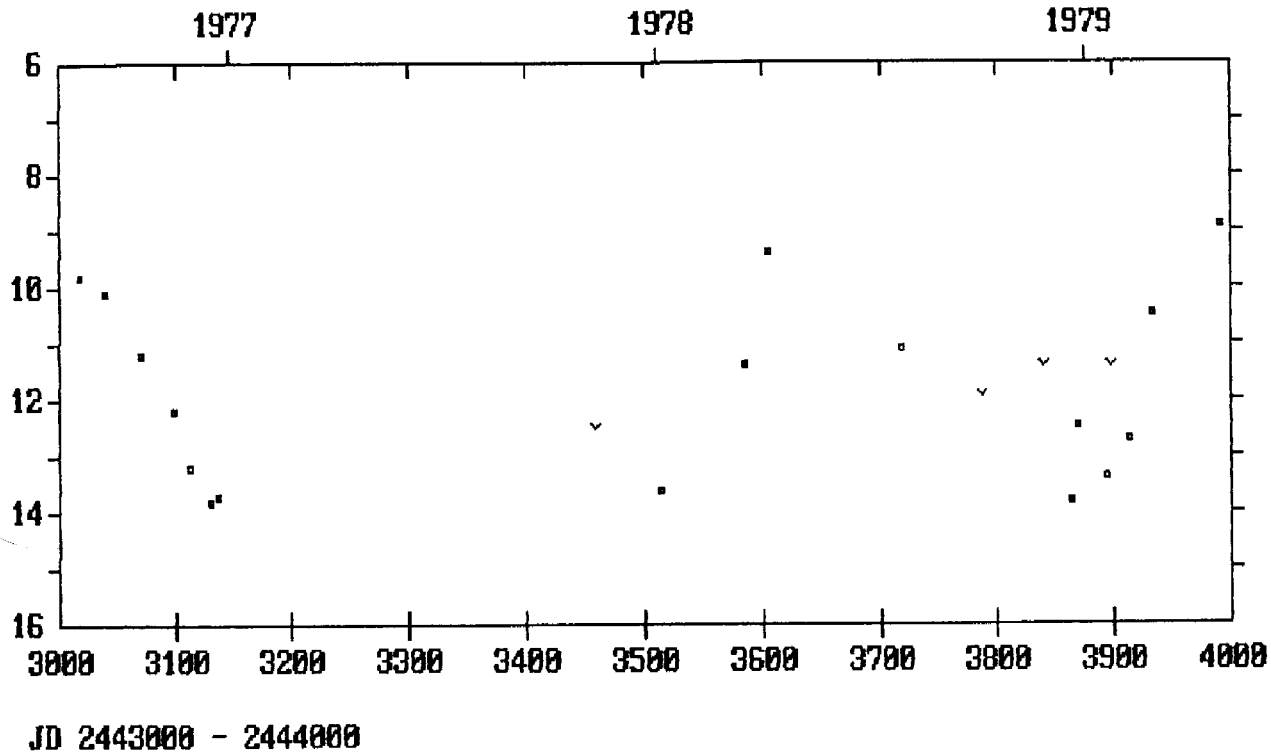



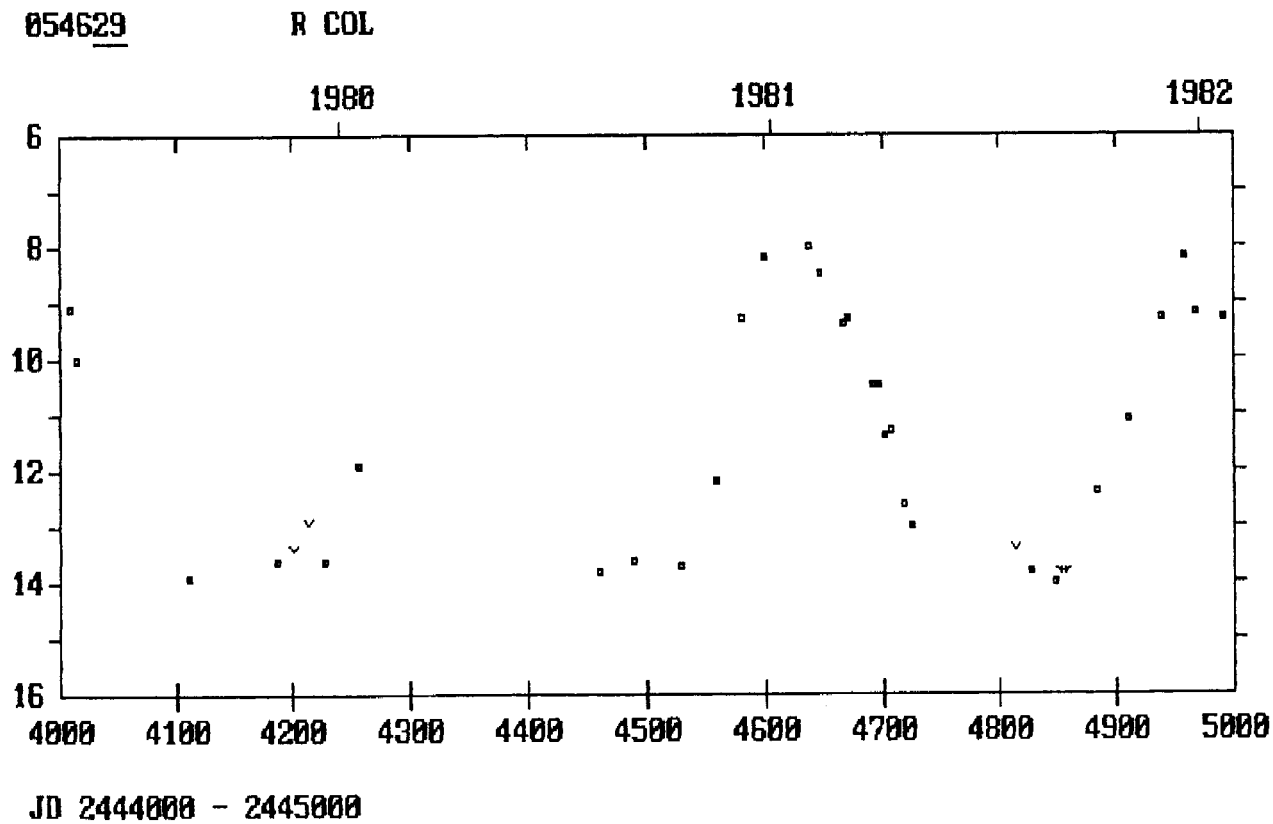

R COL

FIGURE 6

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,441,000 - J.D. 2,443,000



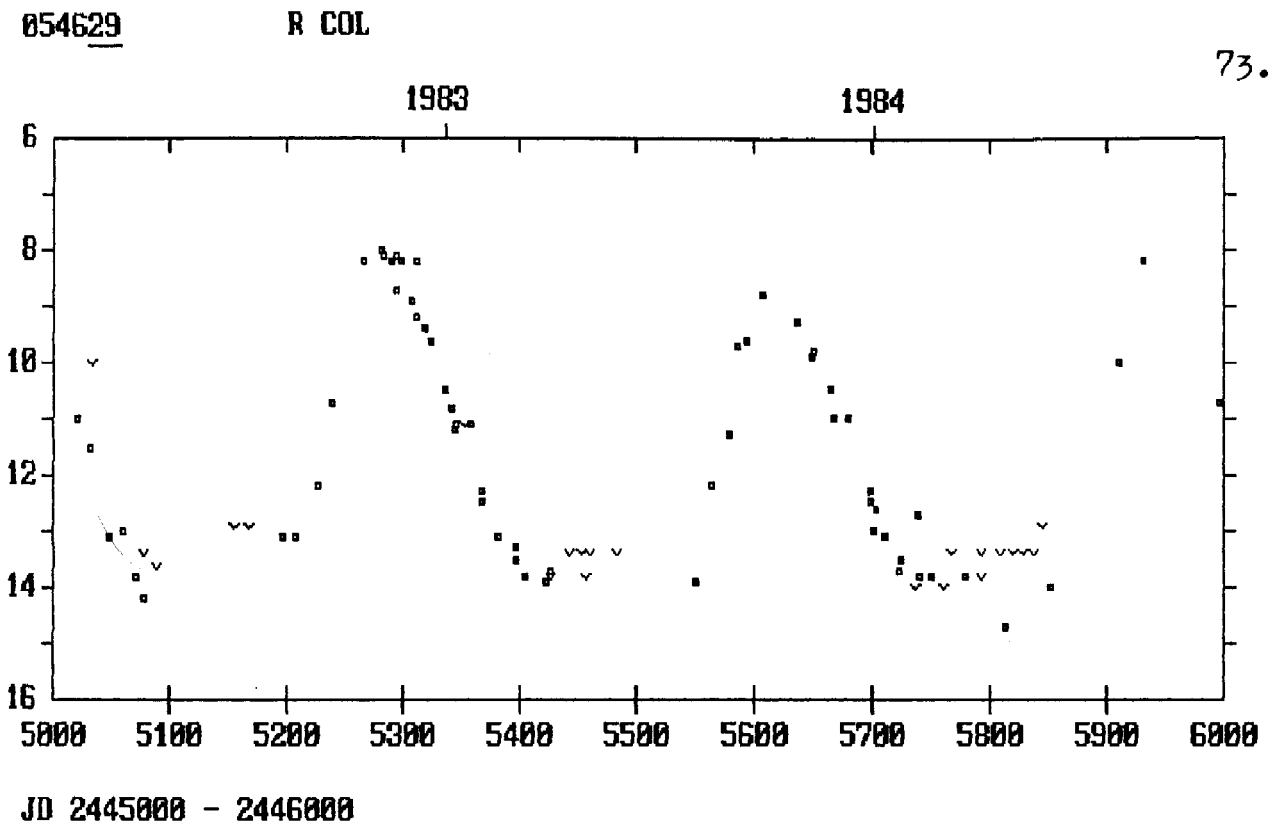



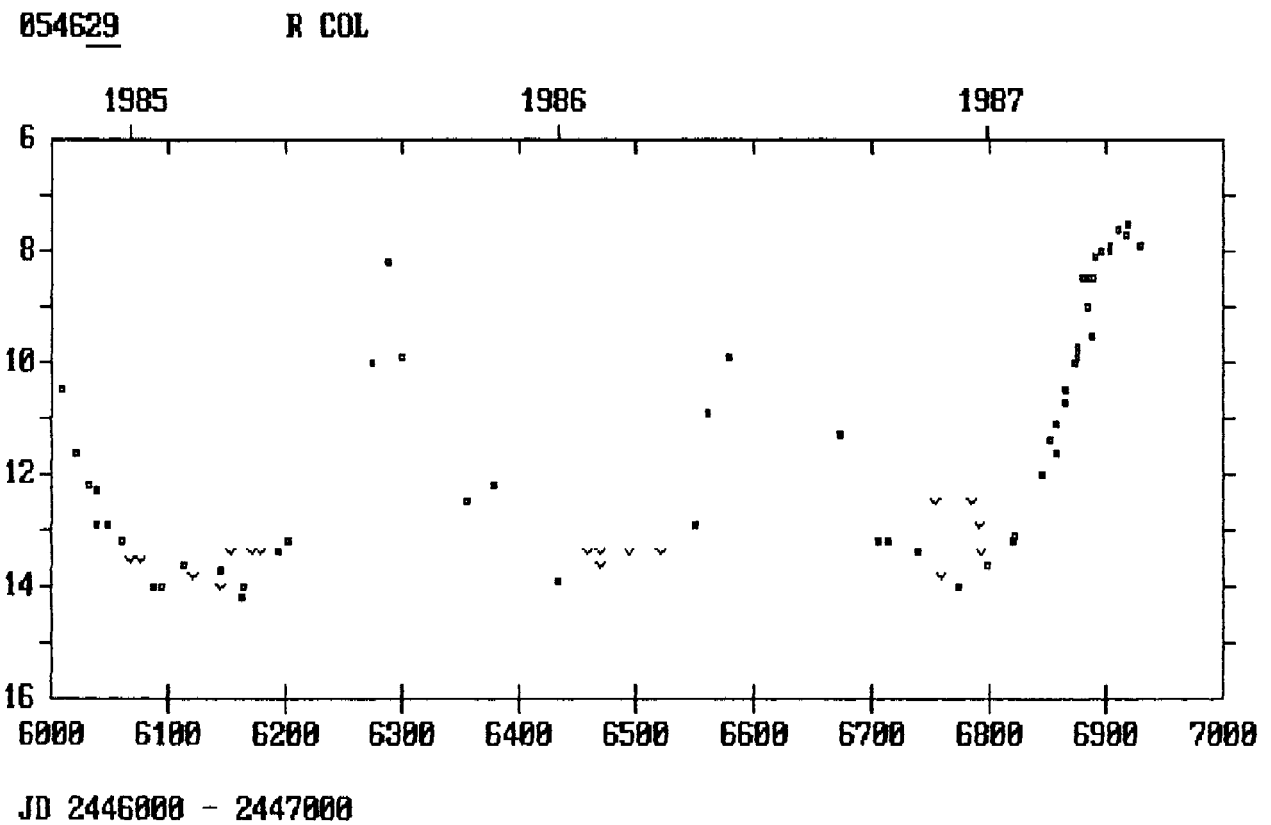

R COL

FIGURE 7

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,443,000 - J.D. 2,445,000



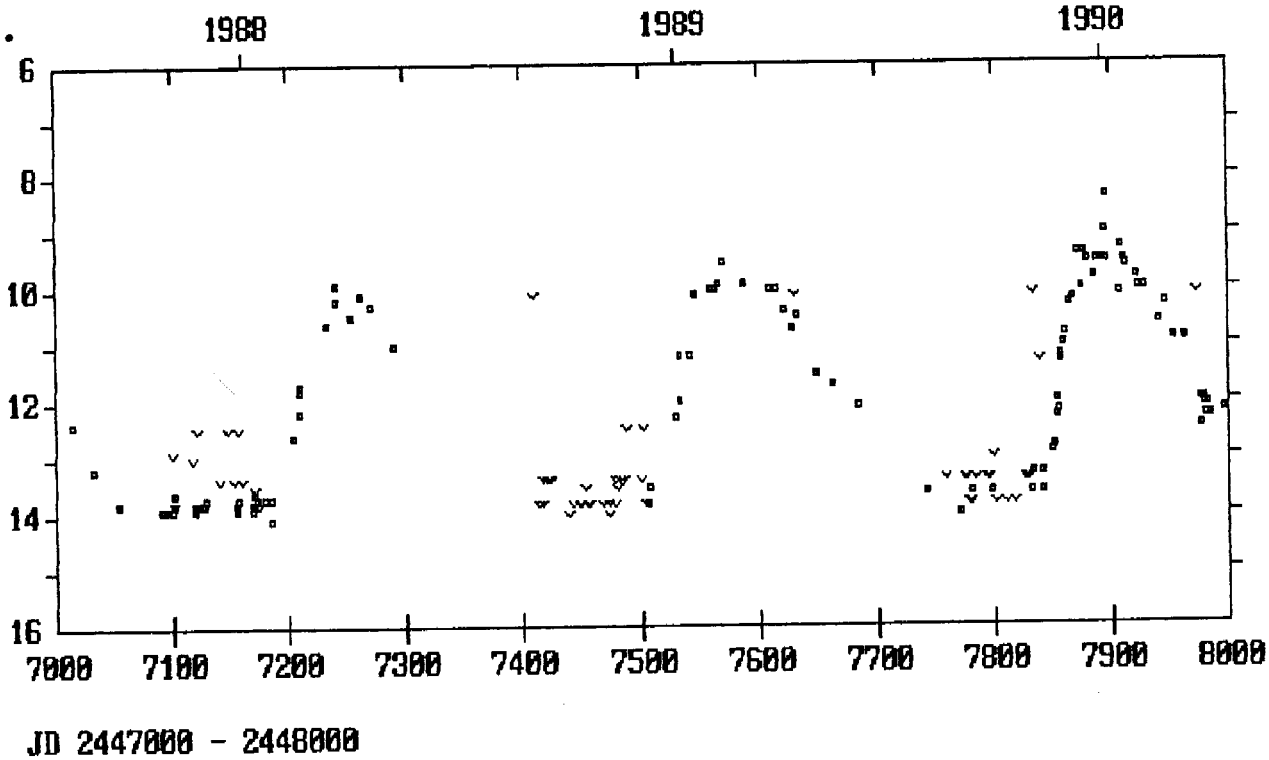



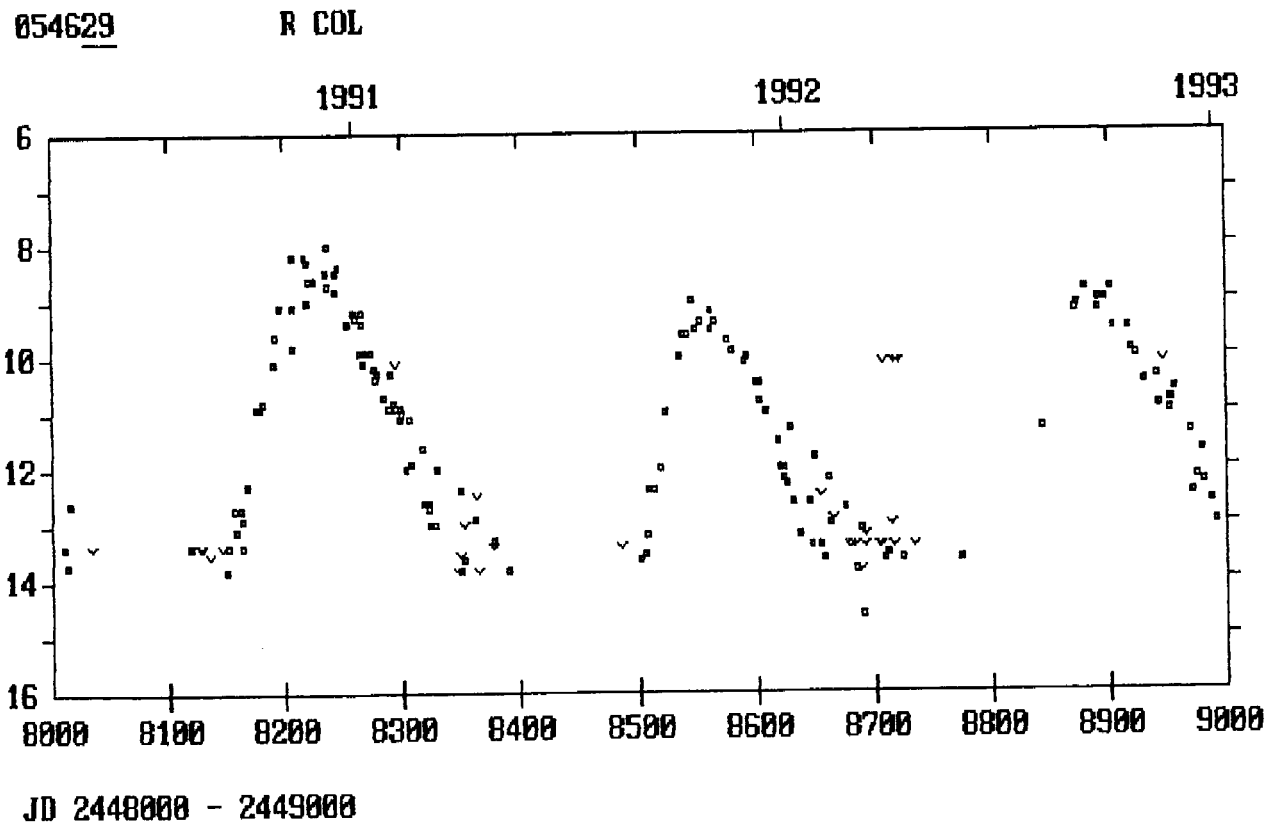

R COL

FIGURE 8

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,445,000 - J.D. 2,447,000



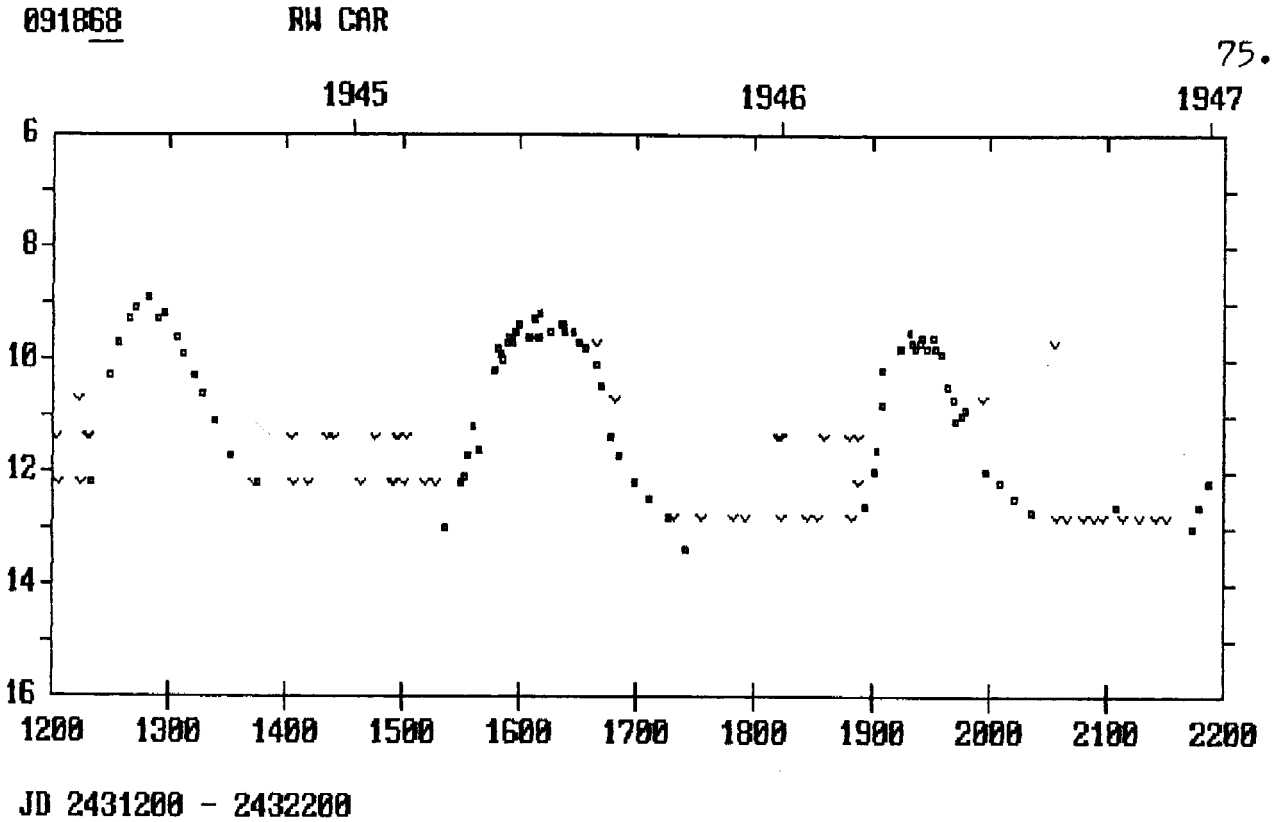



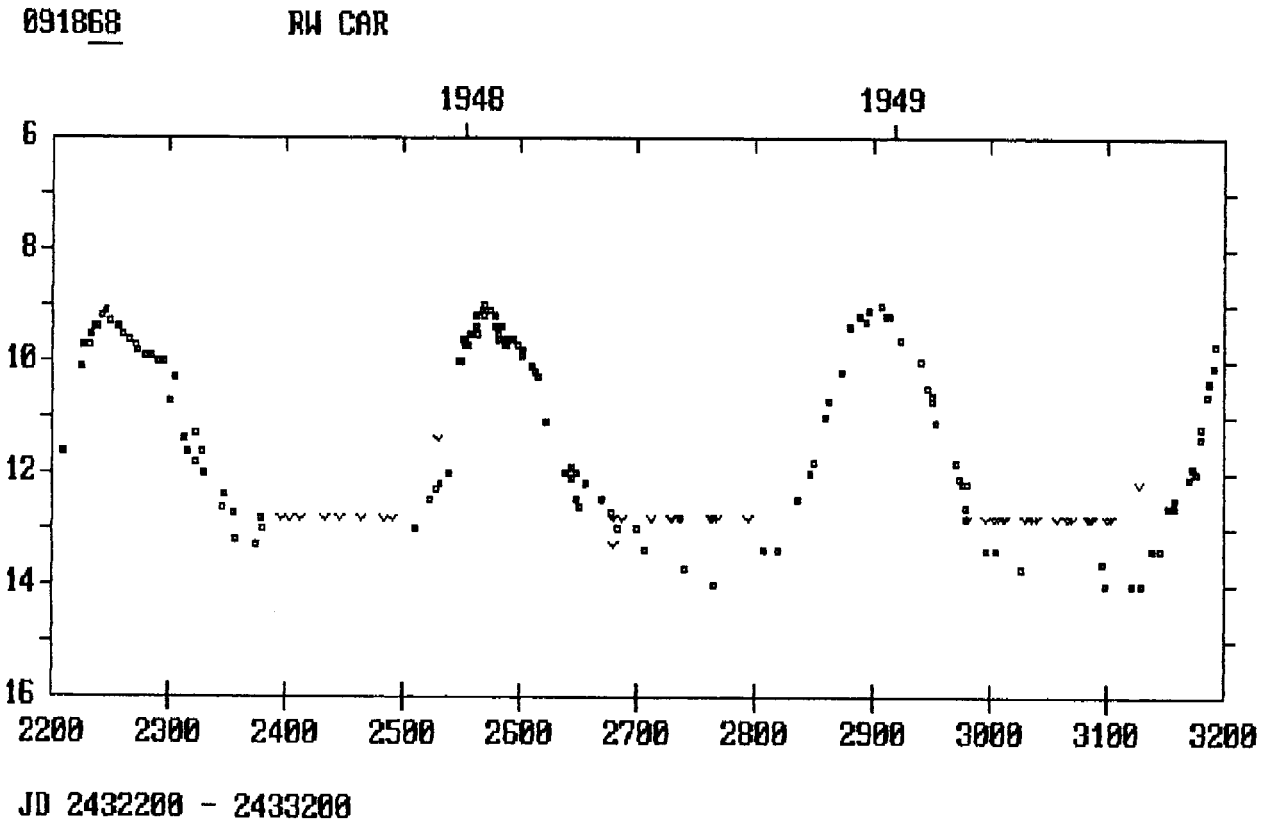

R COL

FIGURE 9

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,447,000 - J.D. 2,449,000



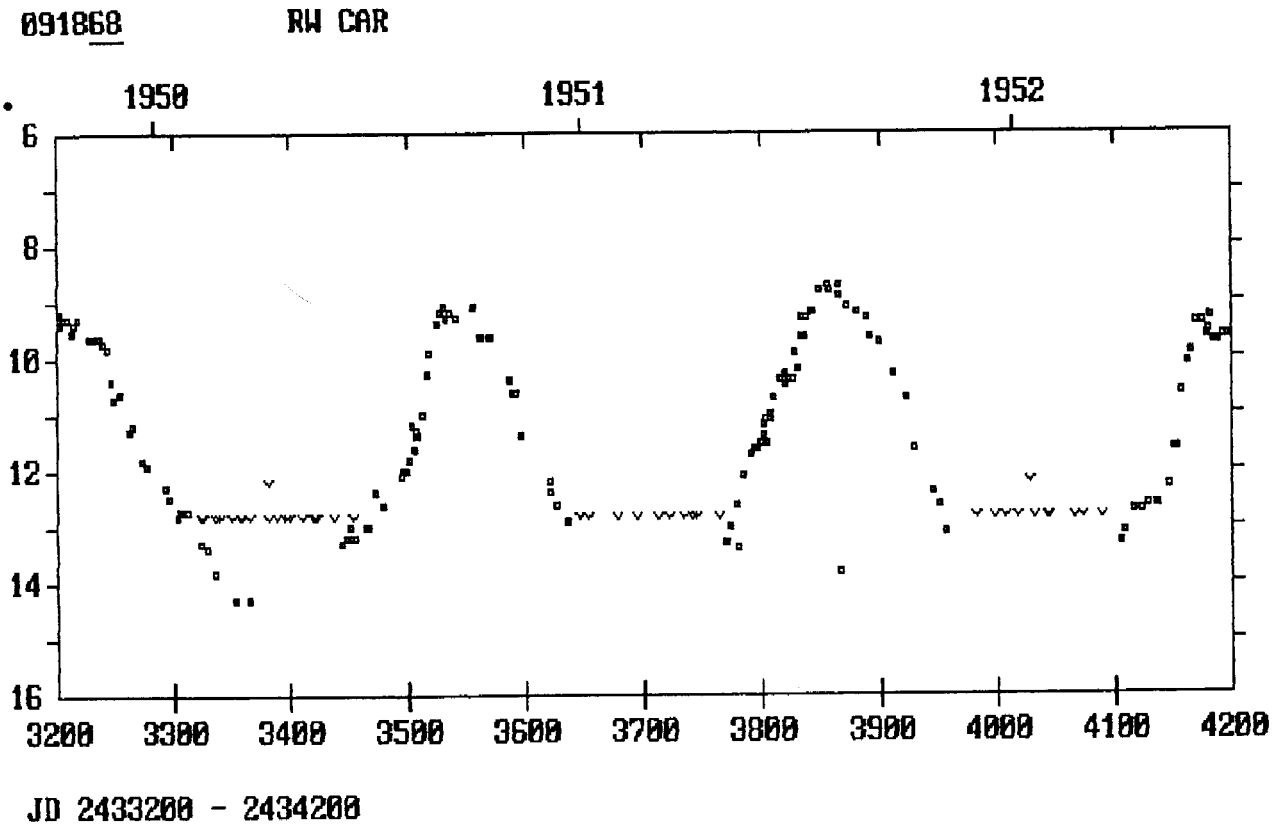



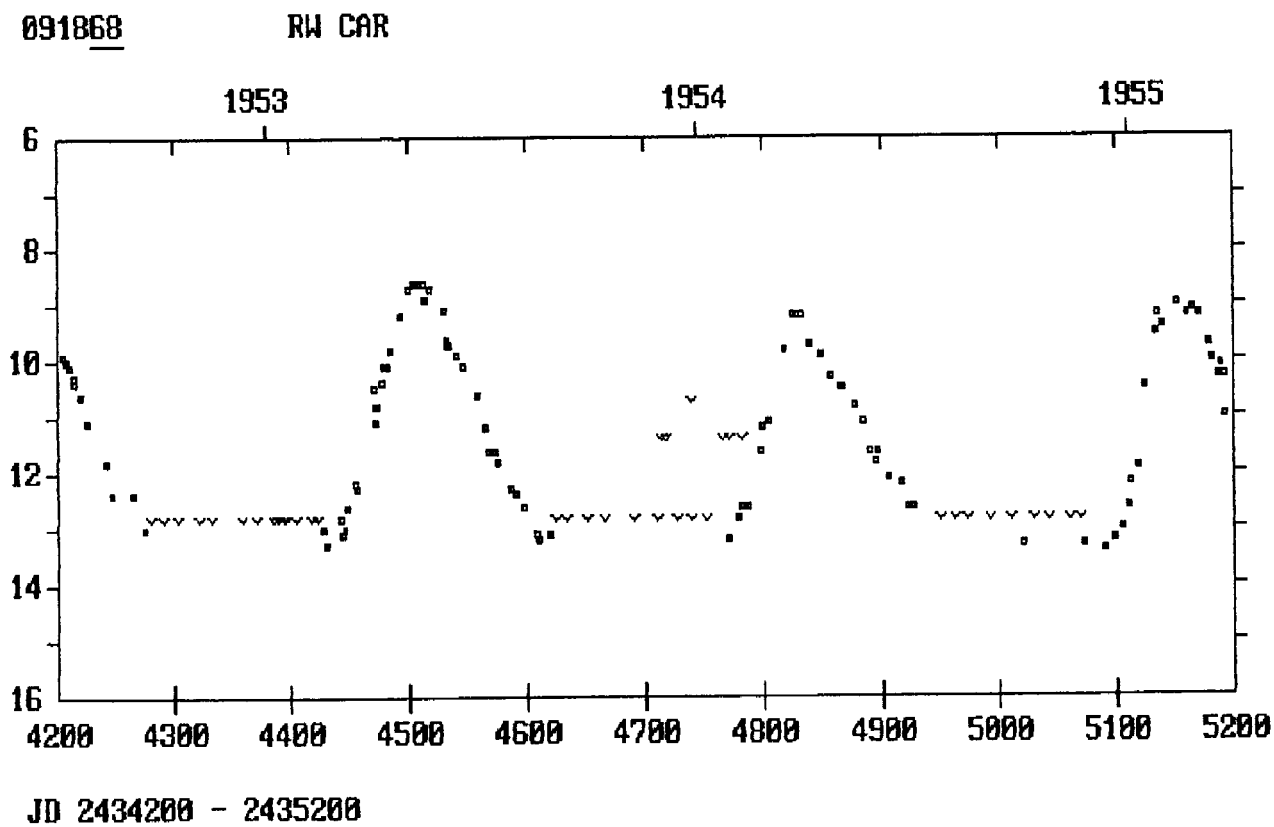

RW CAR

FIGURE 1

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,431,200 - J.D. 2,433,200



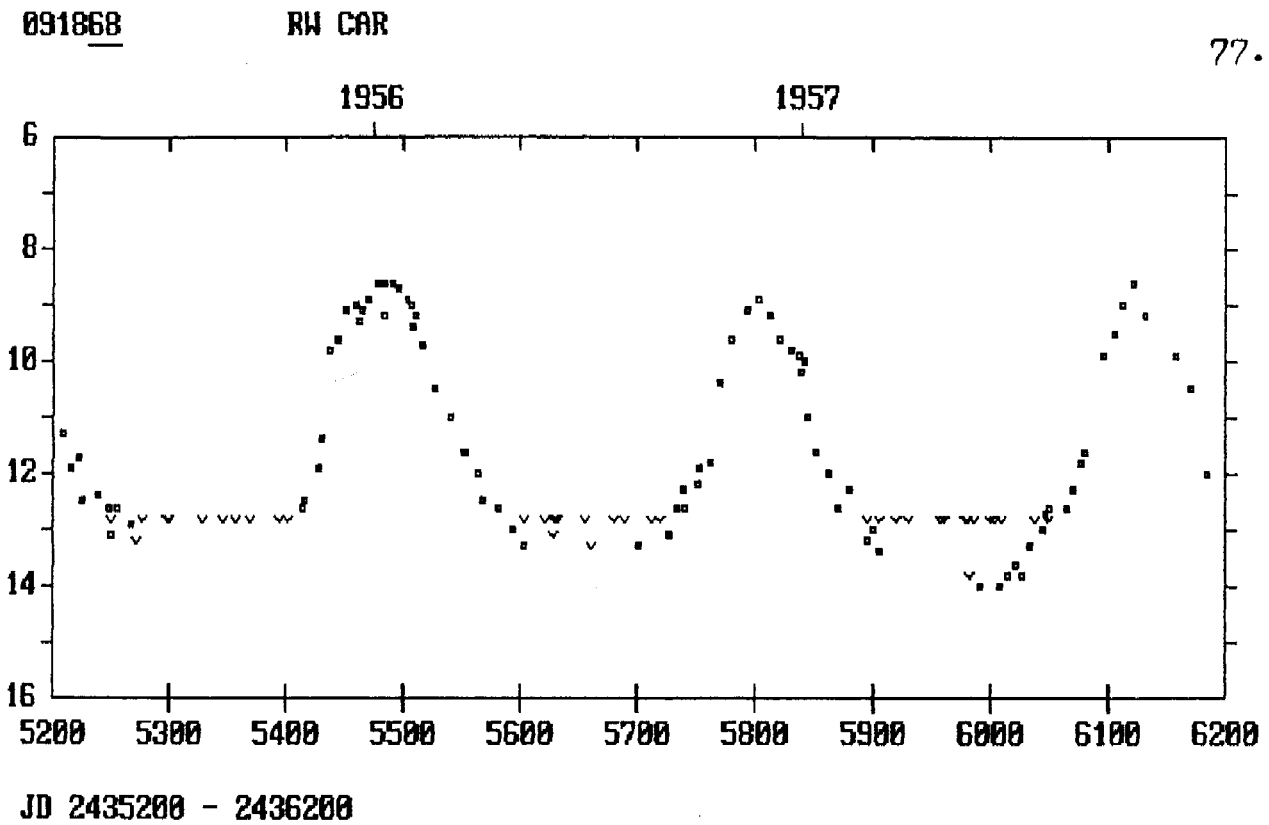



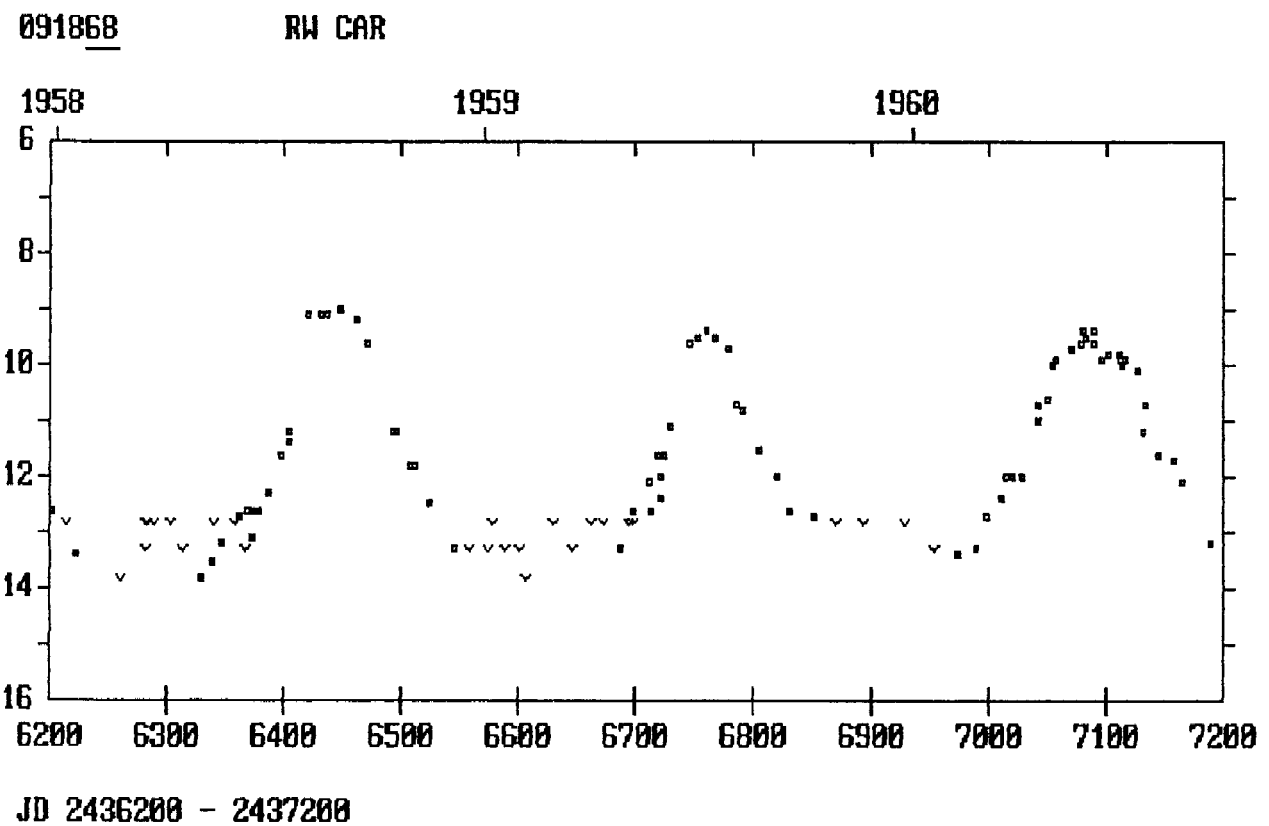

RW CAR

FIGURE 2

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,433,200 - J.D. 2,435,200



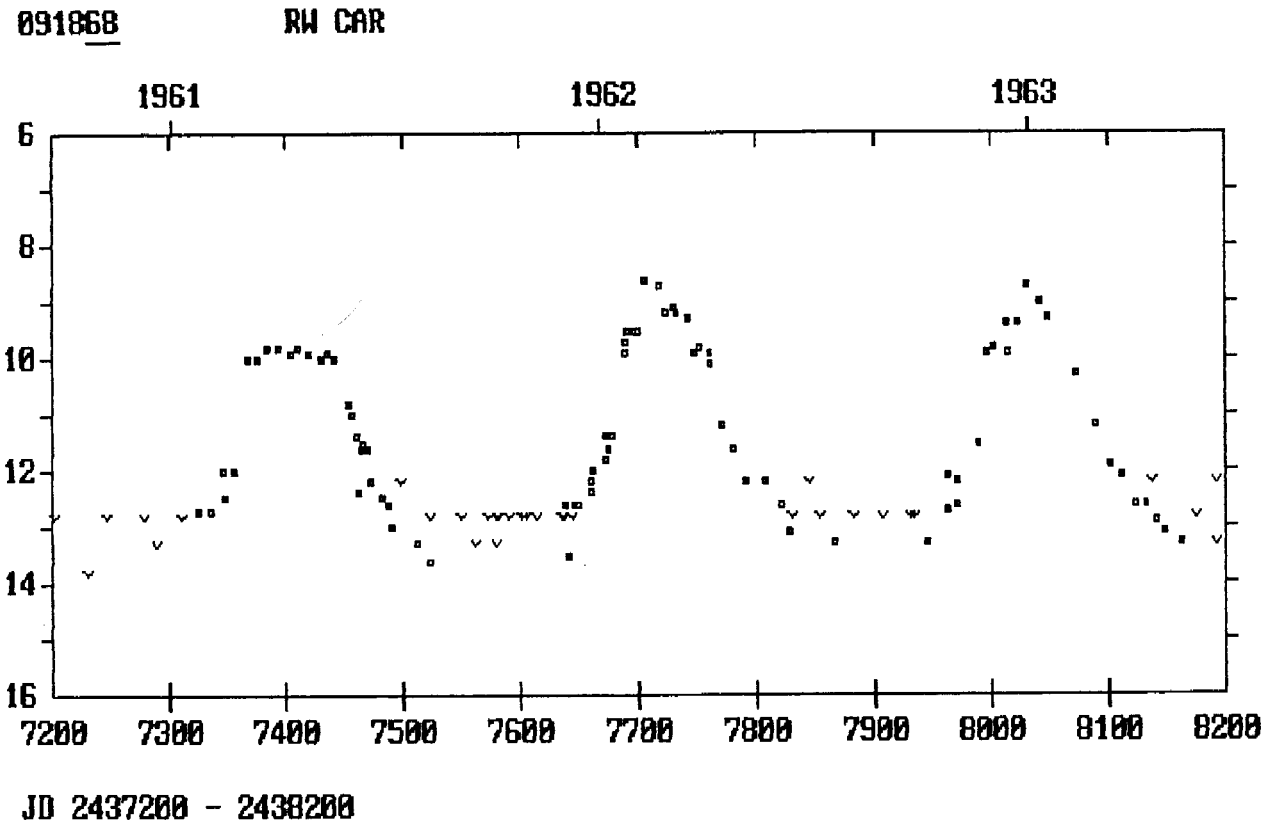




RW CAR

FIGURE 3

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,435,200 - J.D. 2,437,200



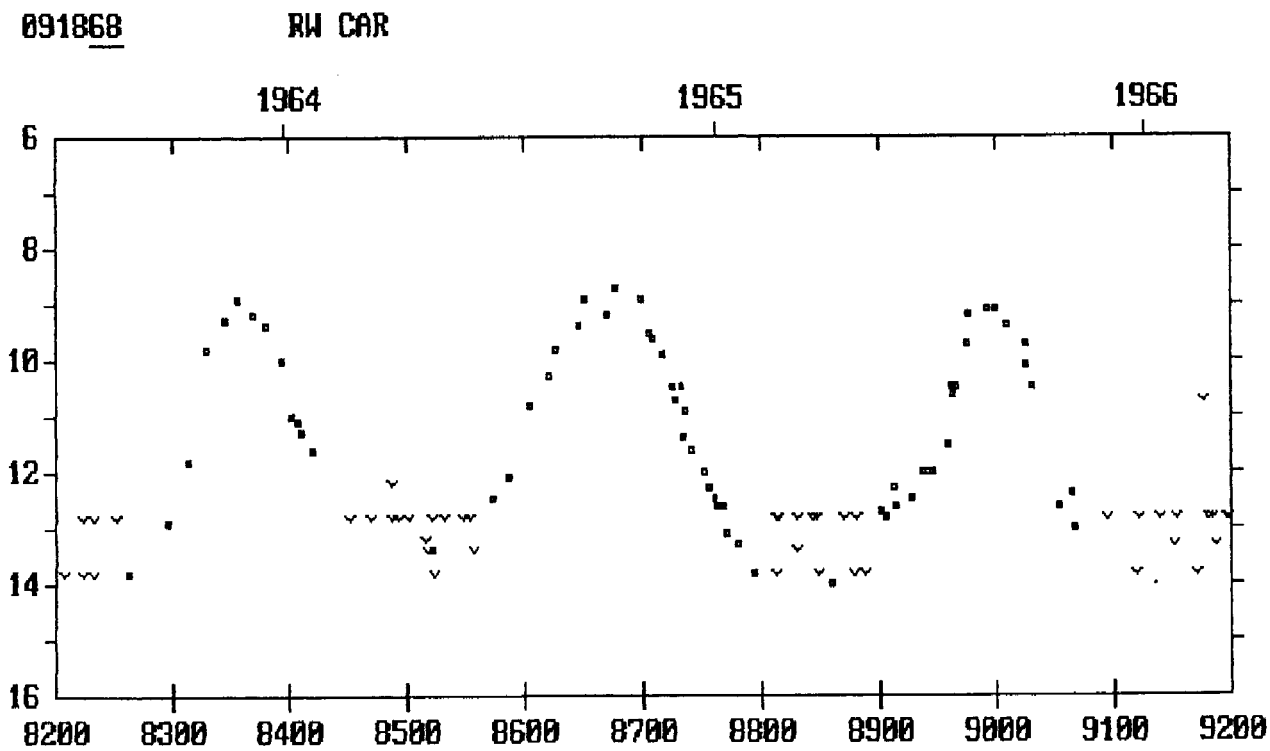
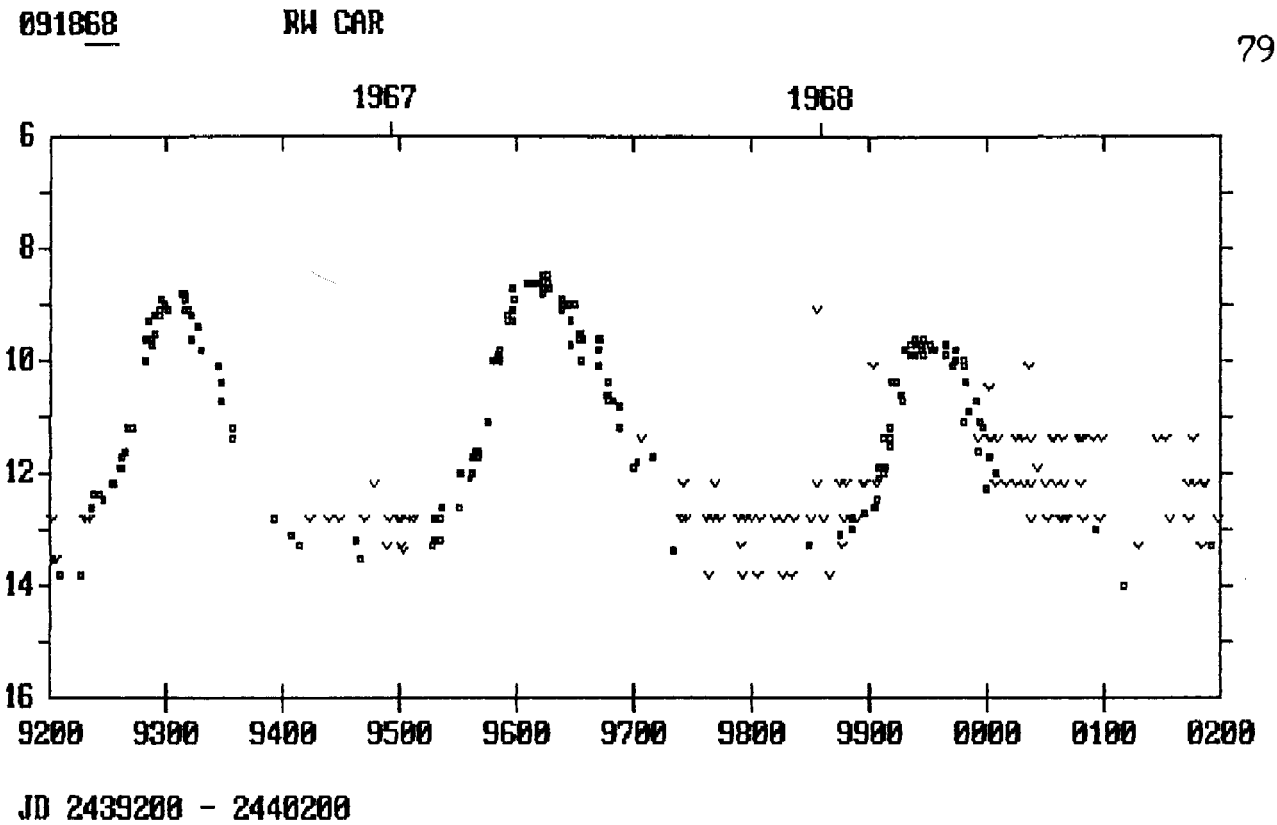
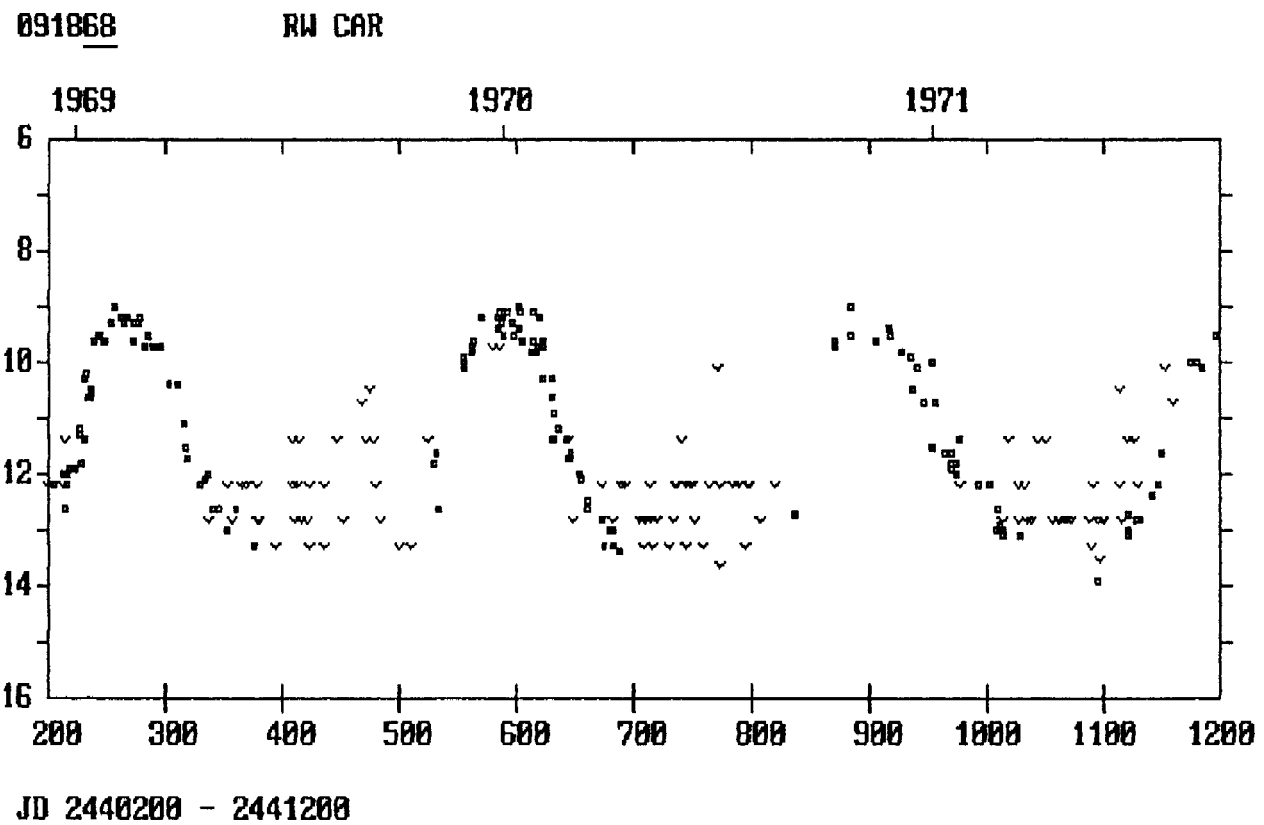




FIGURE 4
LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS
J.D. 2,437,200 - J.D. 2,439,200

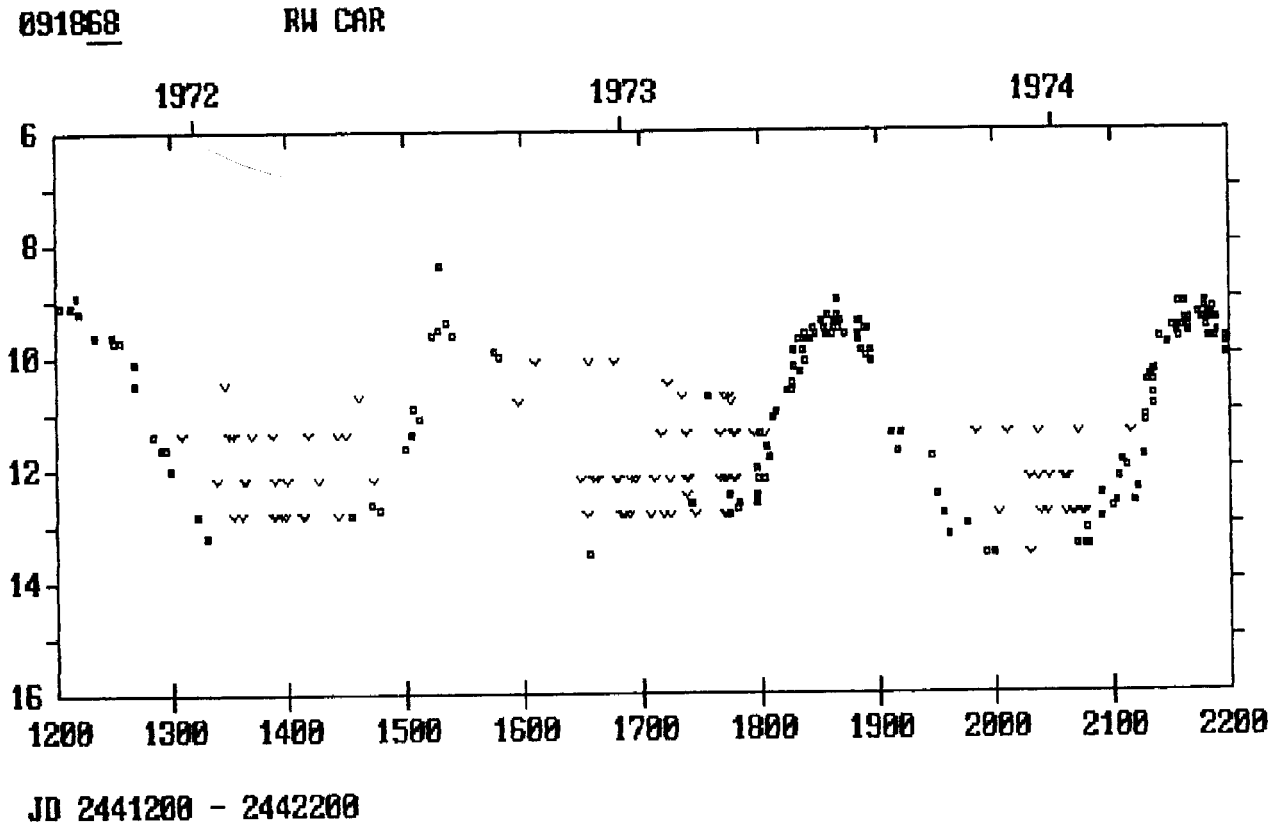


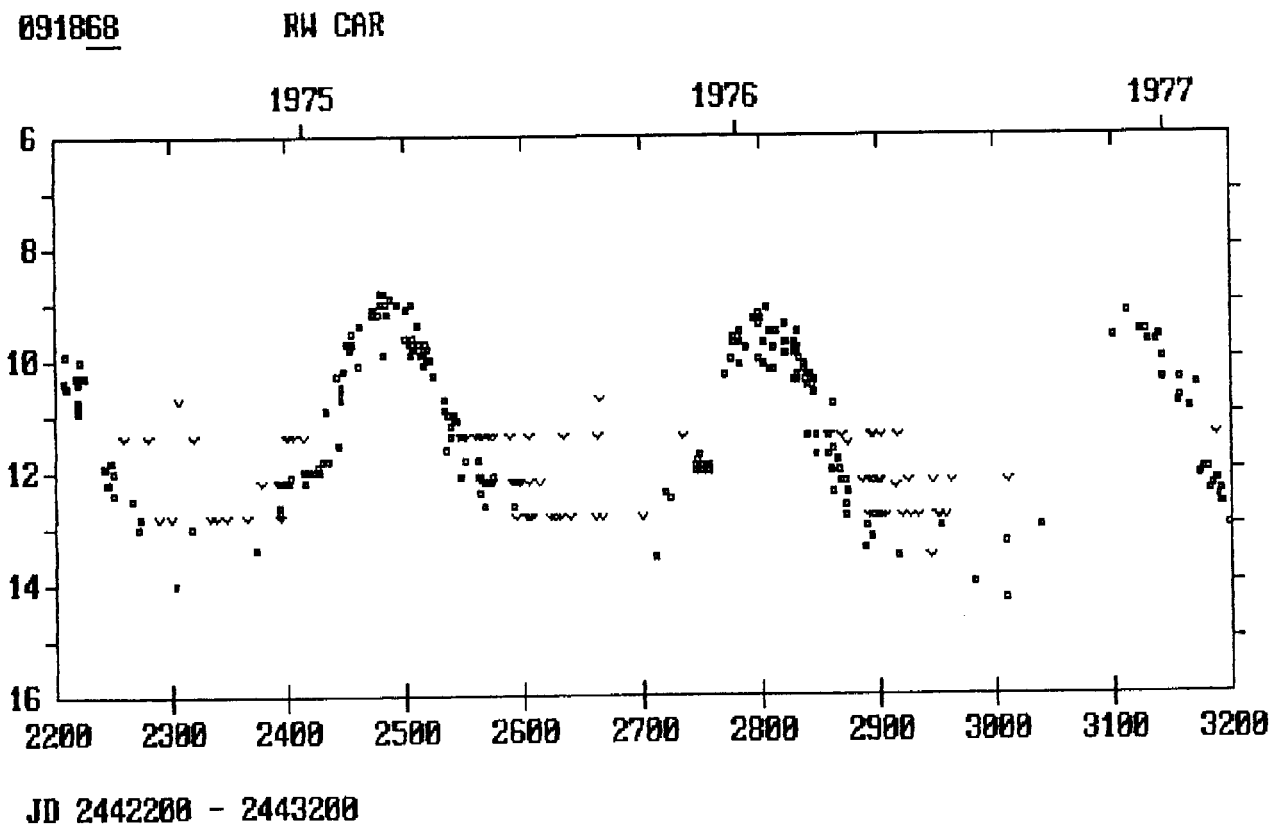




RW CAR FIGURE 5

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,439,200 - J.D. 2,441,200



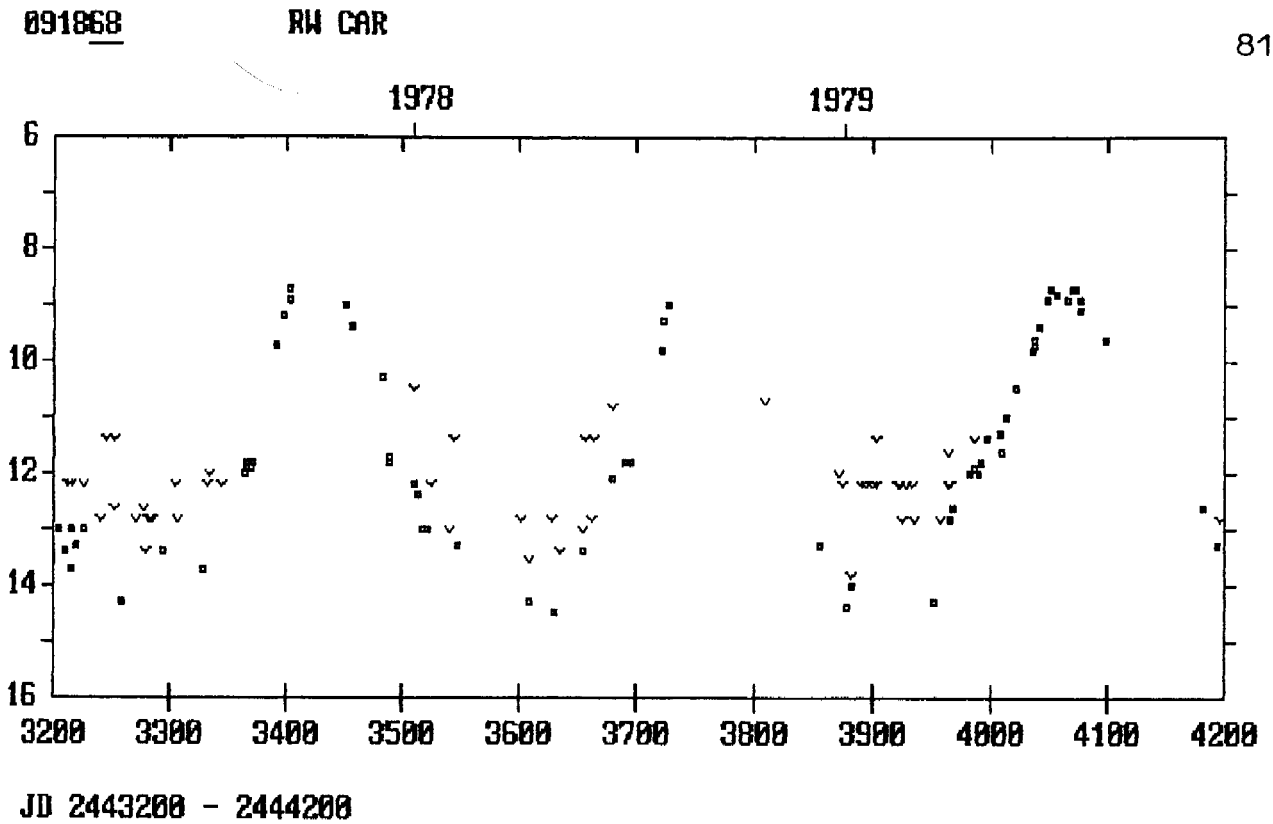



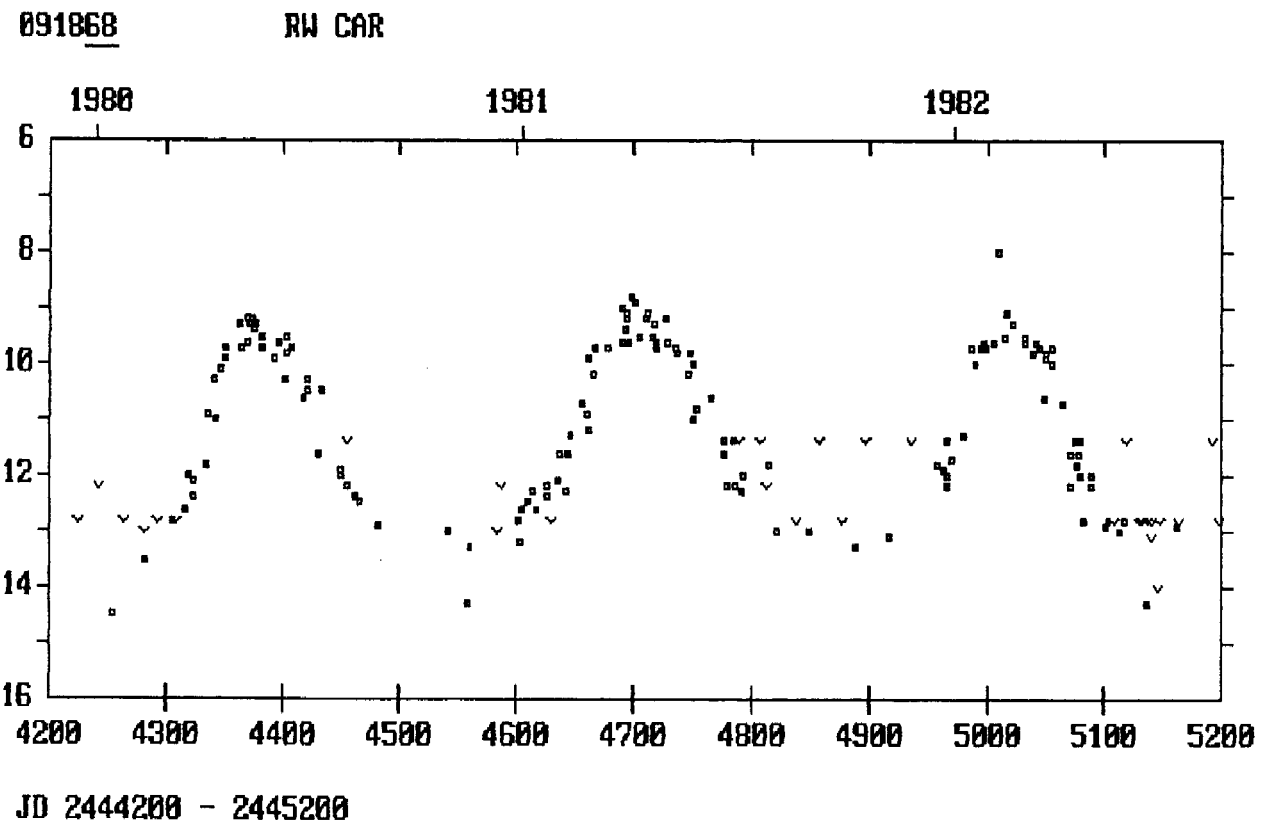

RW CAR

FIGURE 6

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,441,200 - J.D. 2,443,200



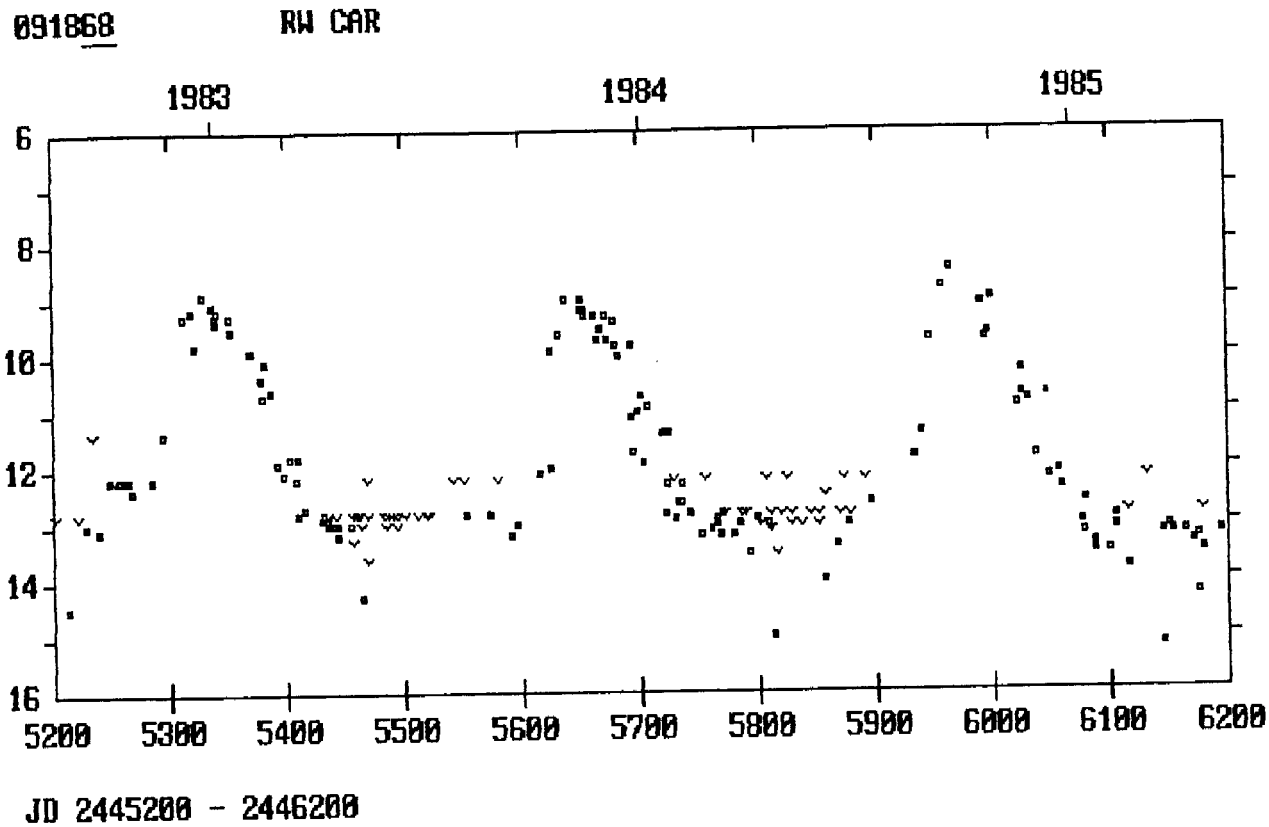



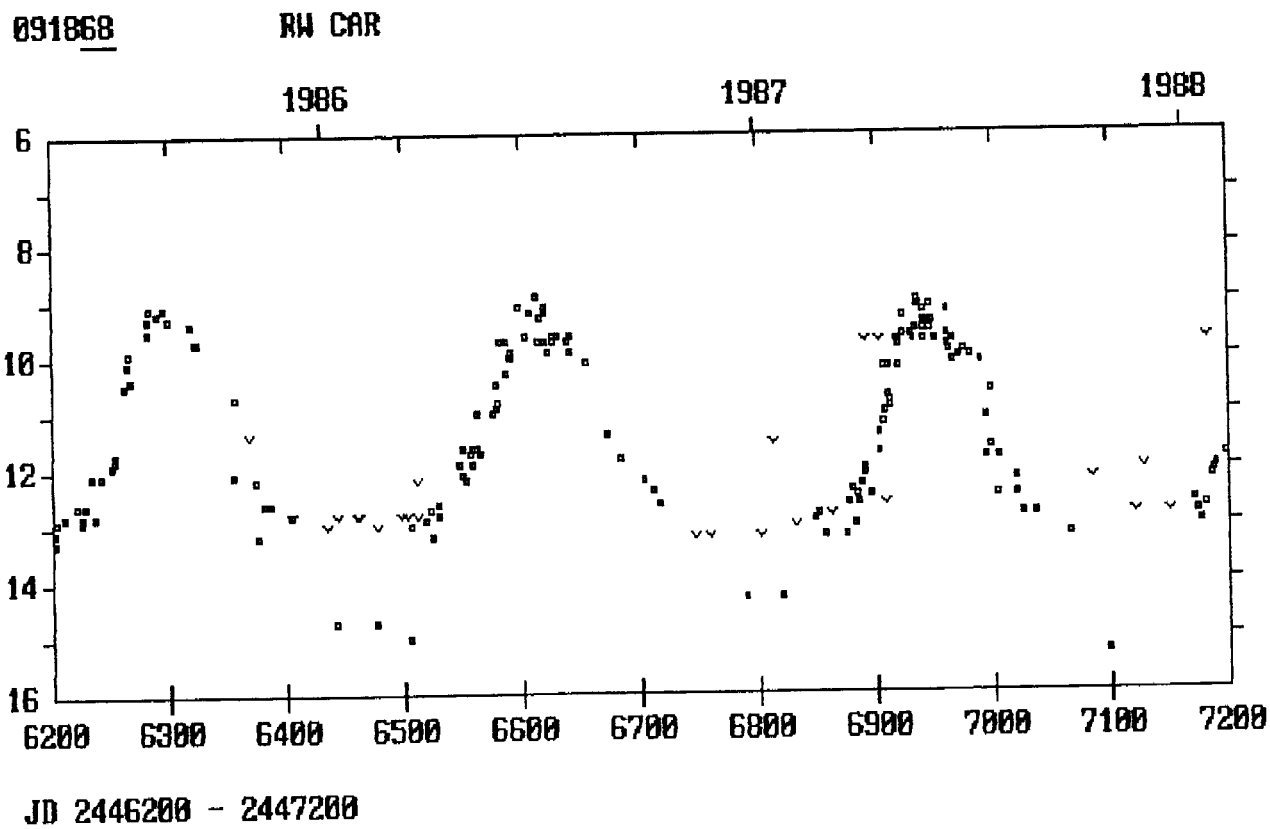

RW CAR

FIGURE 7

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,443,200 - J.D. 2,445,200



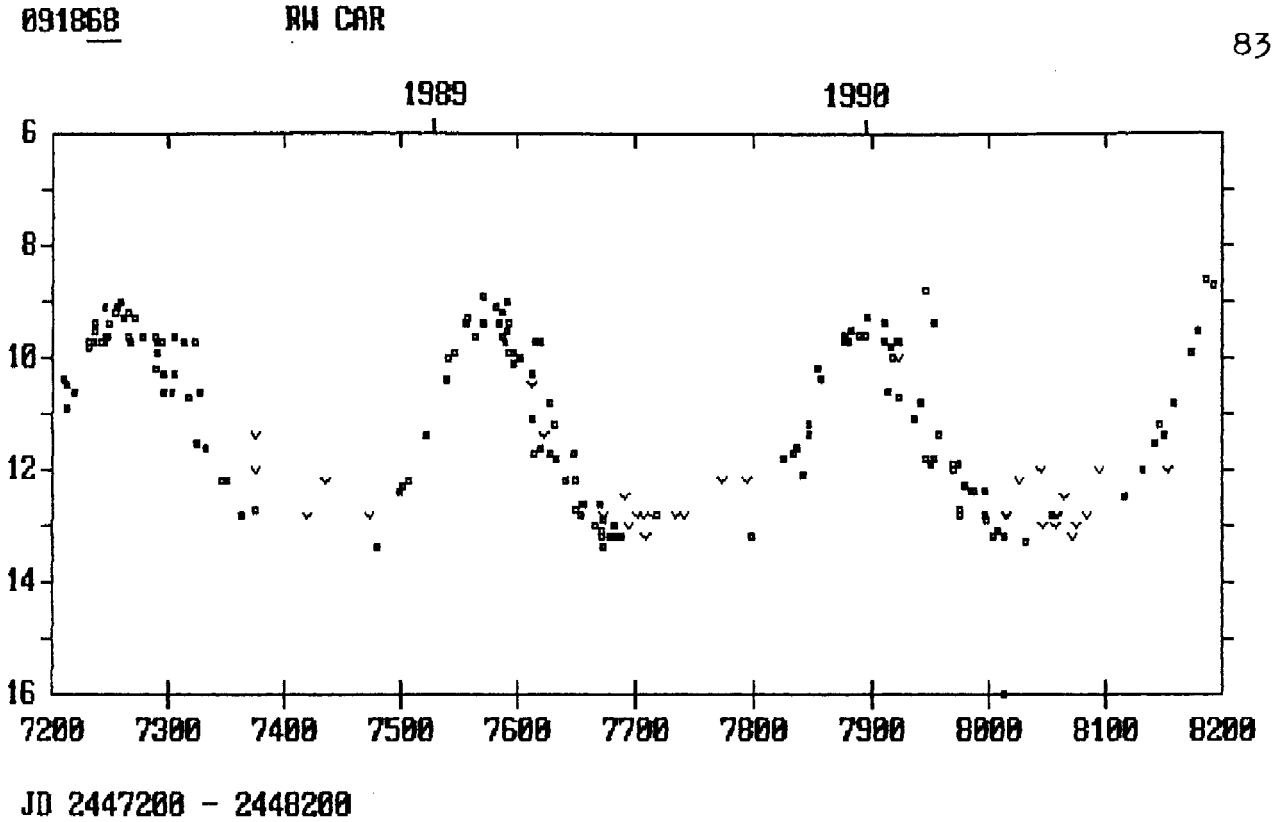



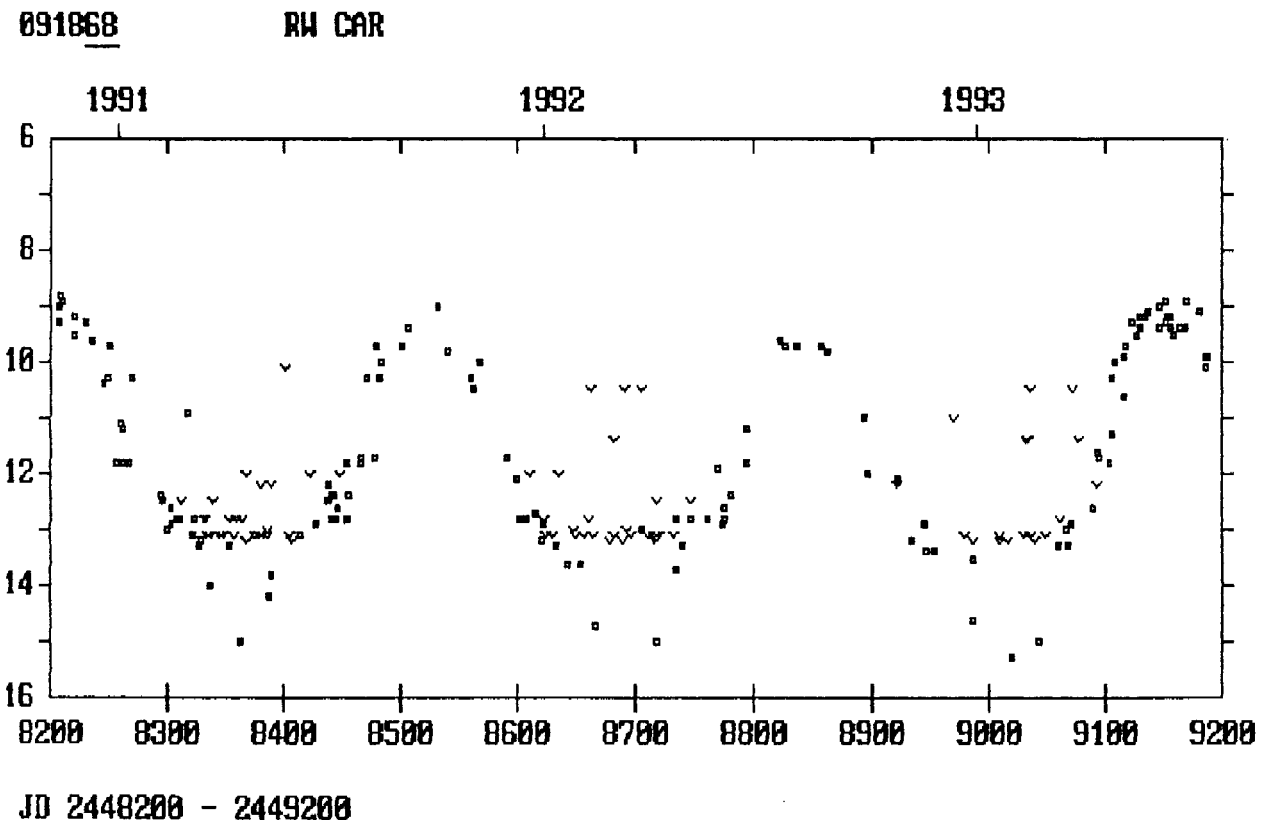

RW CAR

FIGURE 8

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

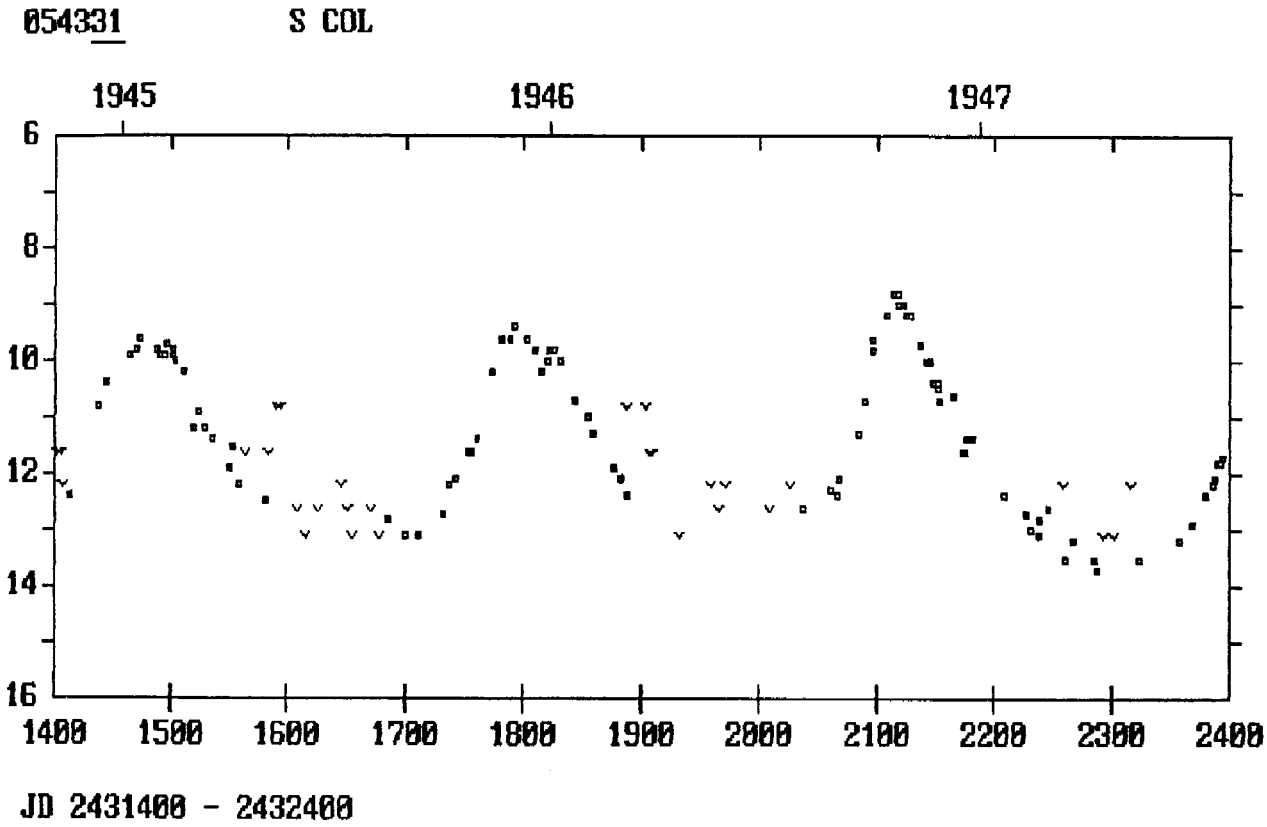
J.D. 2,445,200 - J.D. 2,447,200

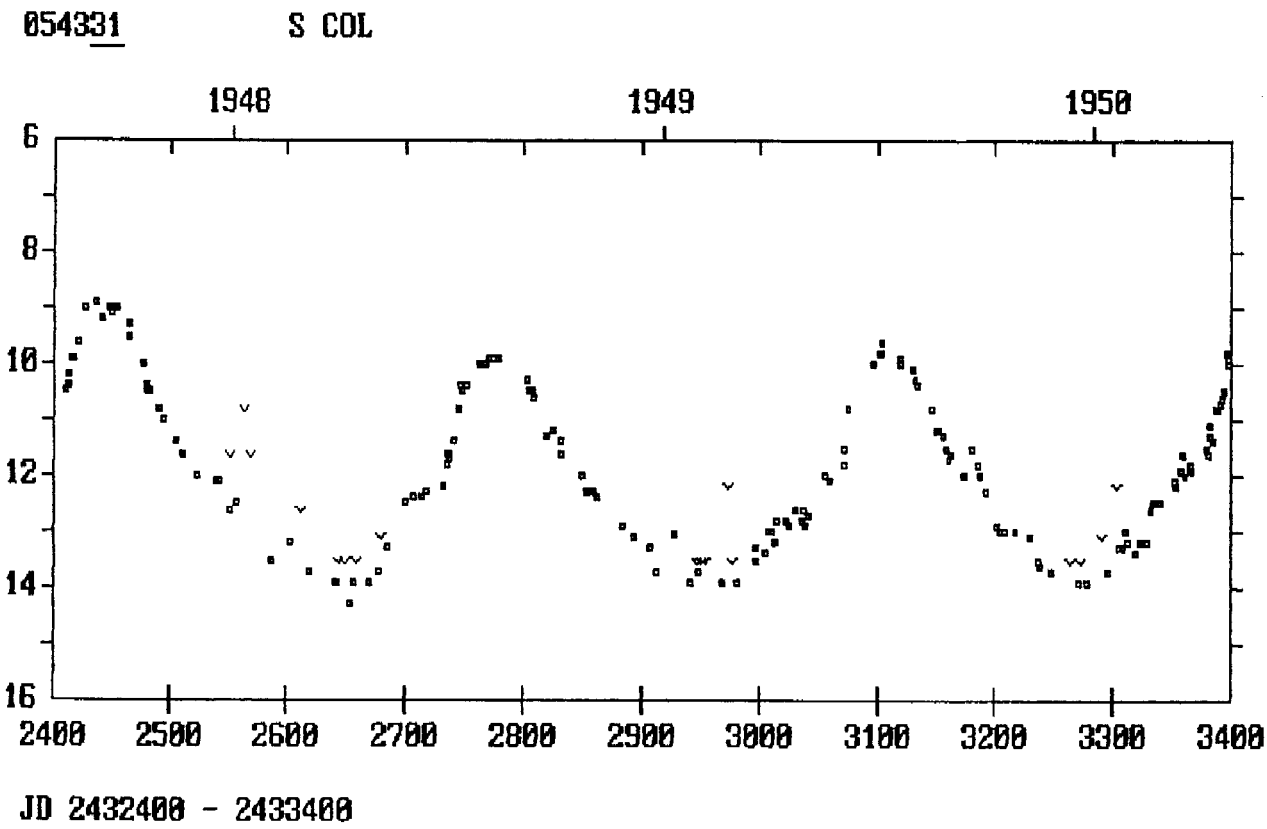



RW CAR FIGURE 9

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS
J.D. 2,447,200 - J.D. 2,449,200



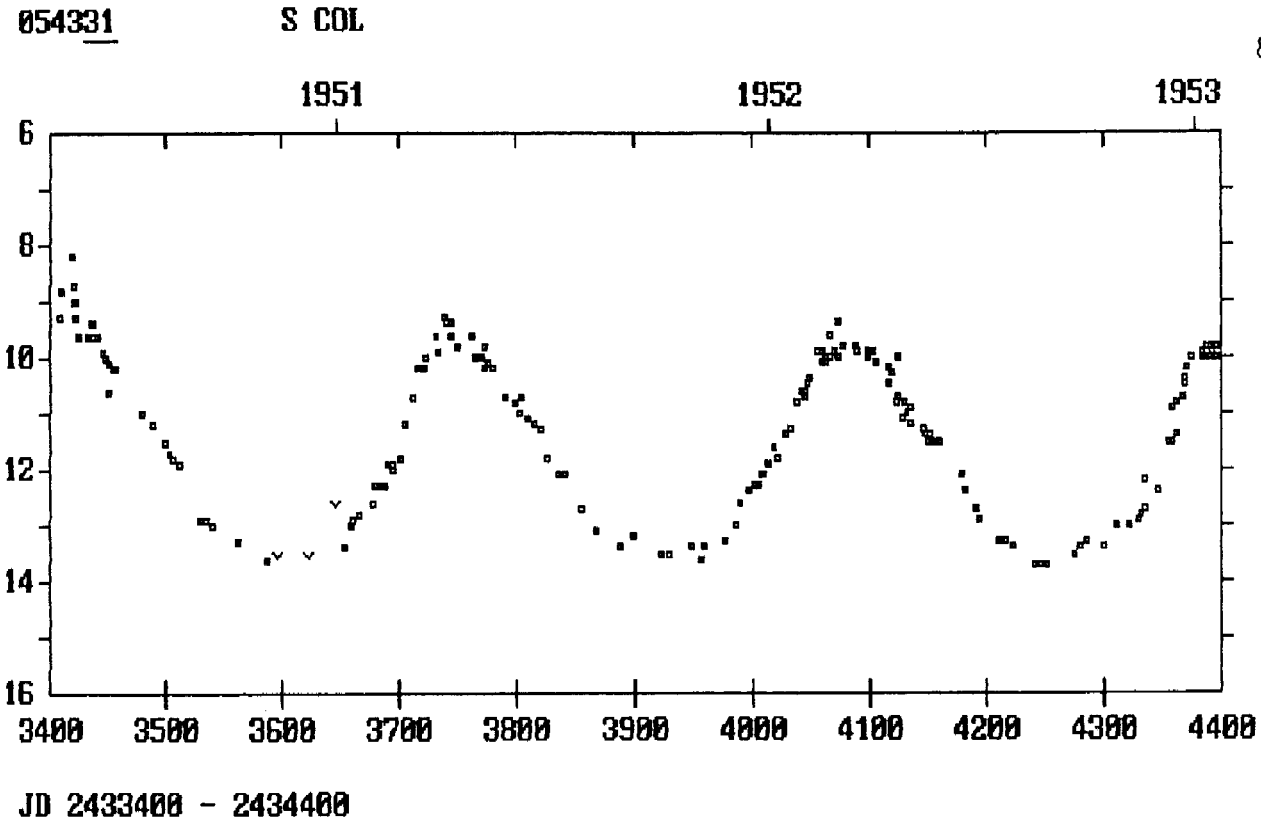



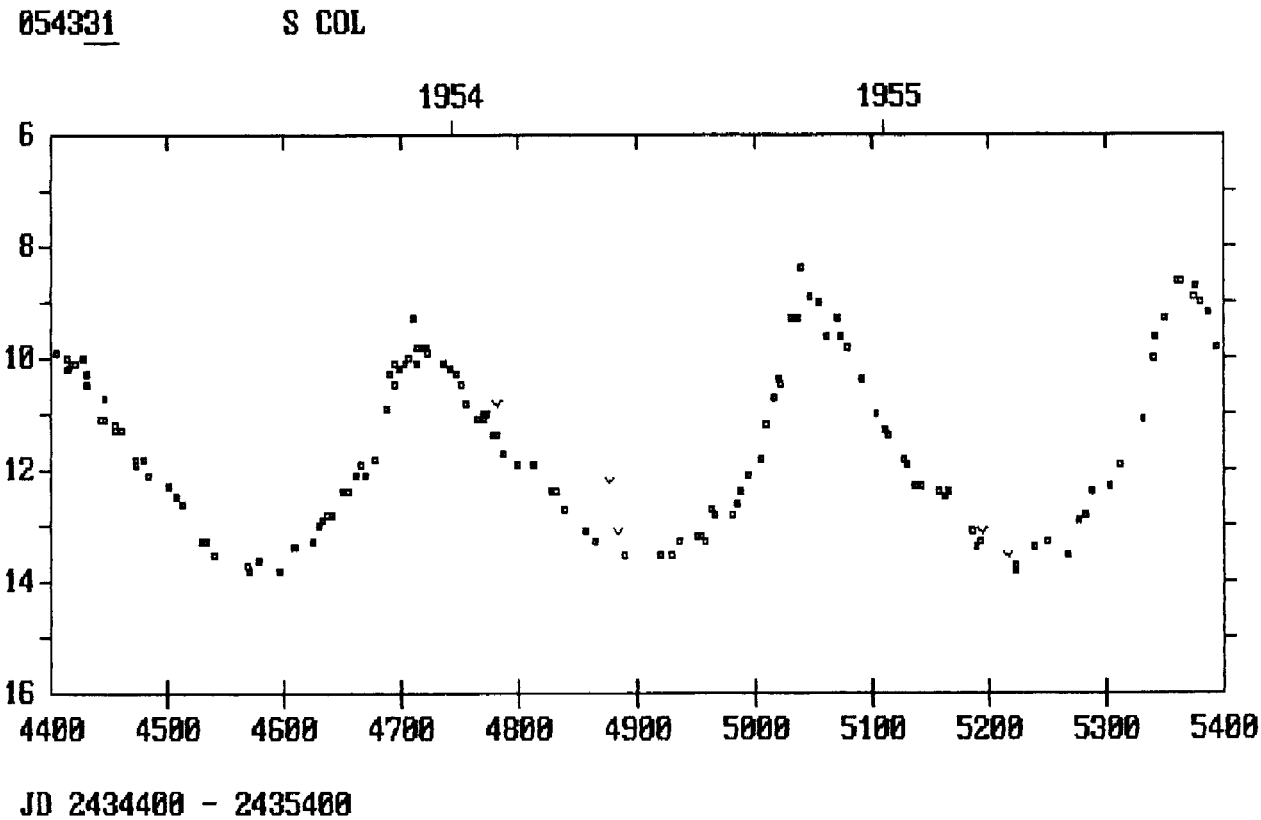

S COL

FIGURE 1

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,431,400 - J.D. 2,433,400



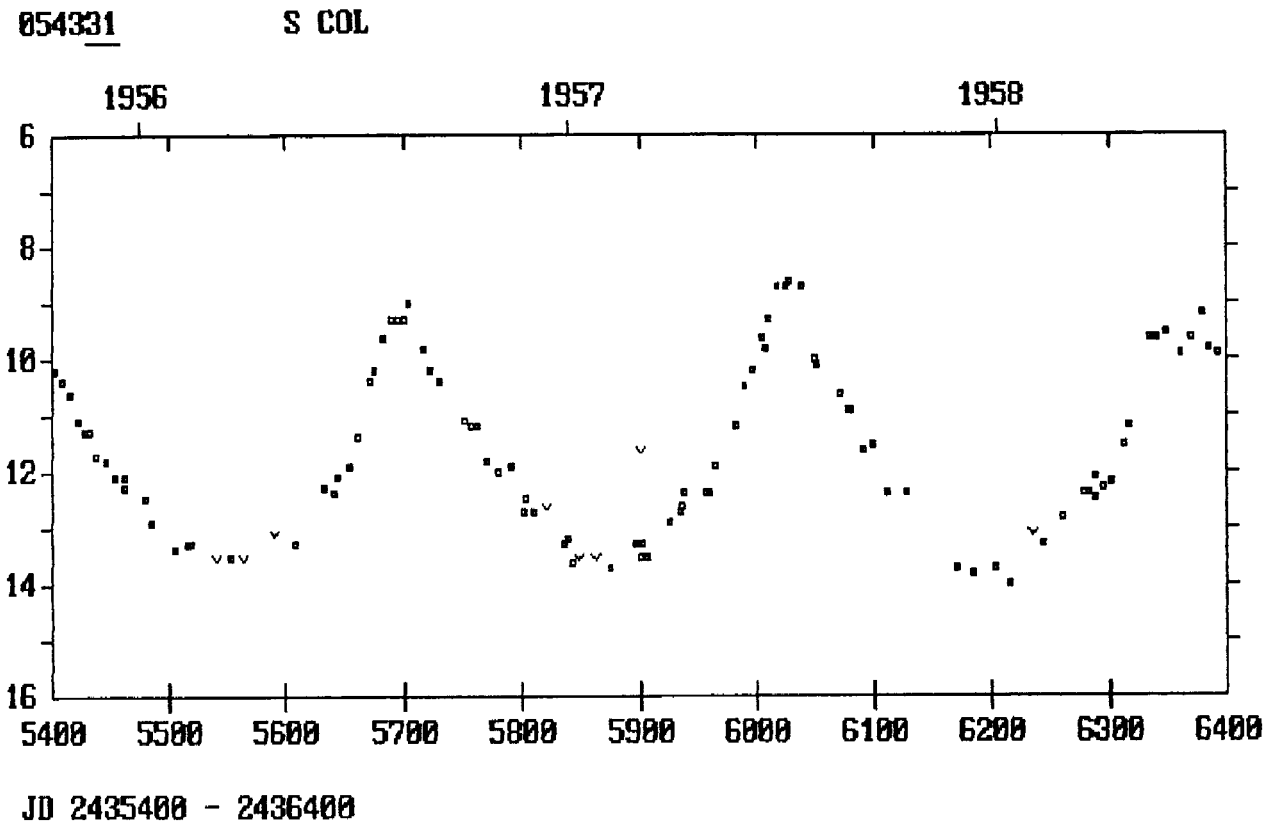



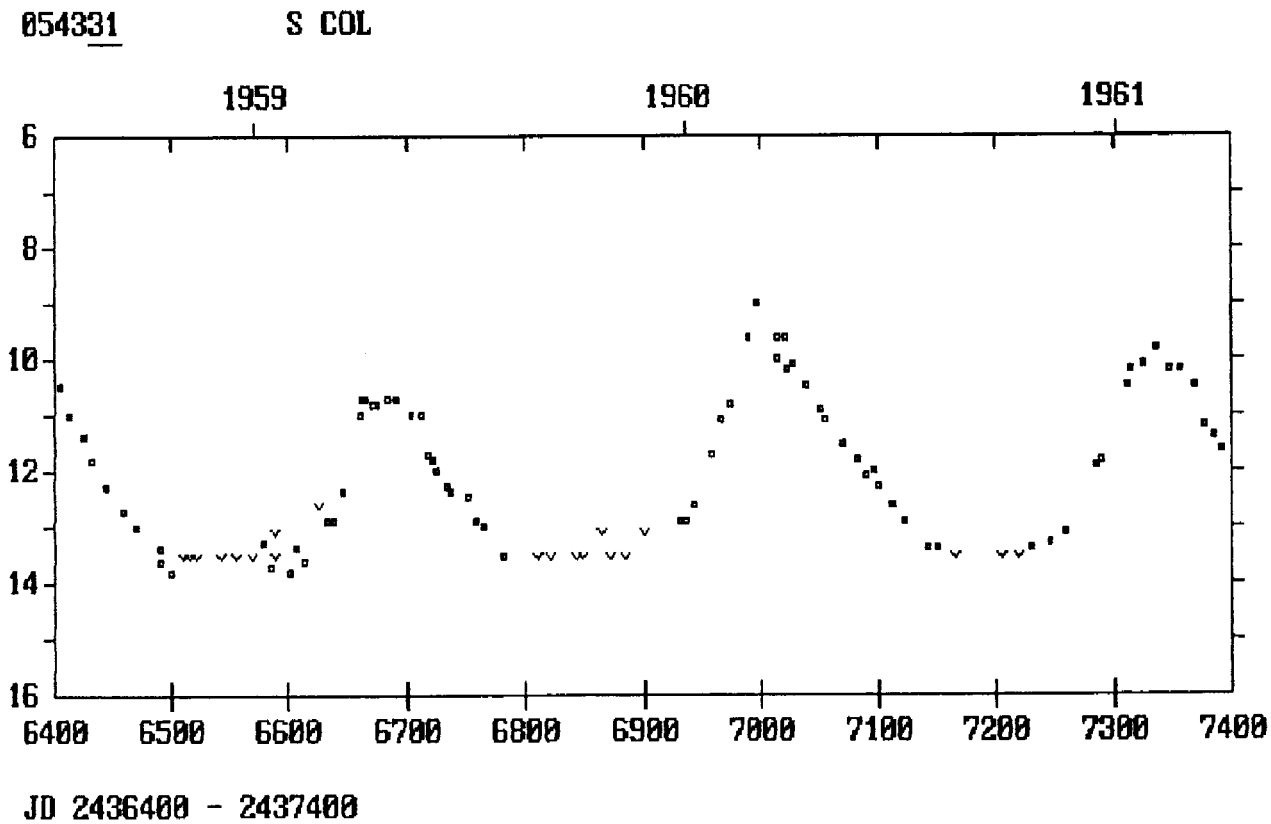

S COL

FIGURE 2

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,433,400 - J.D. 2,435,400



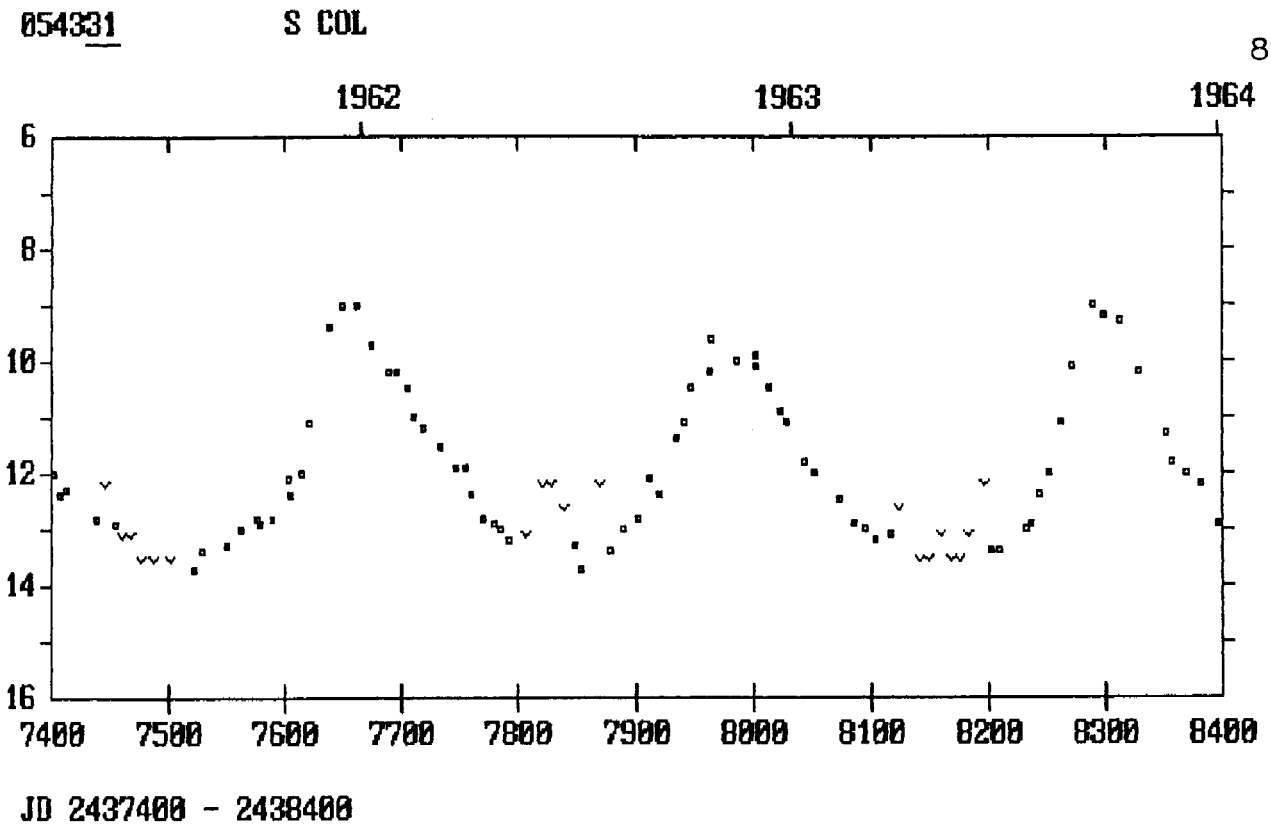



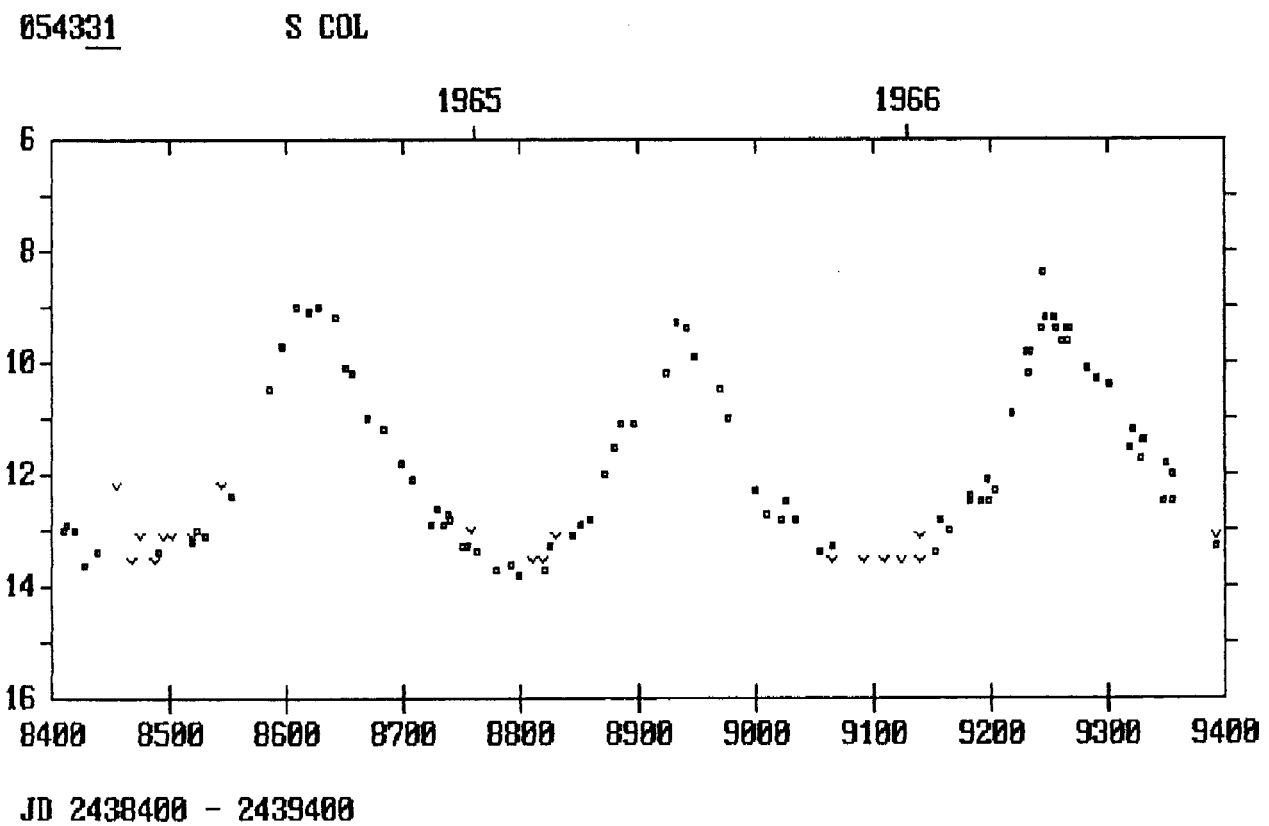

S COL

FIGURE 3

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,435,400 - J.D. 2,437,400



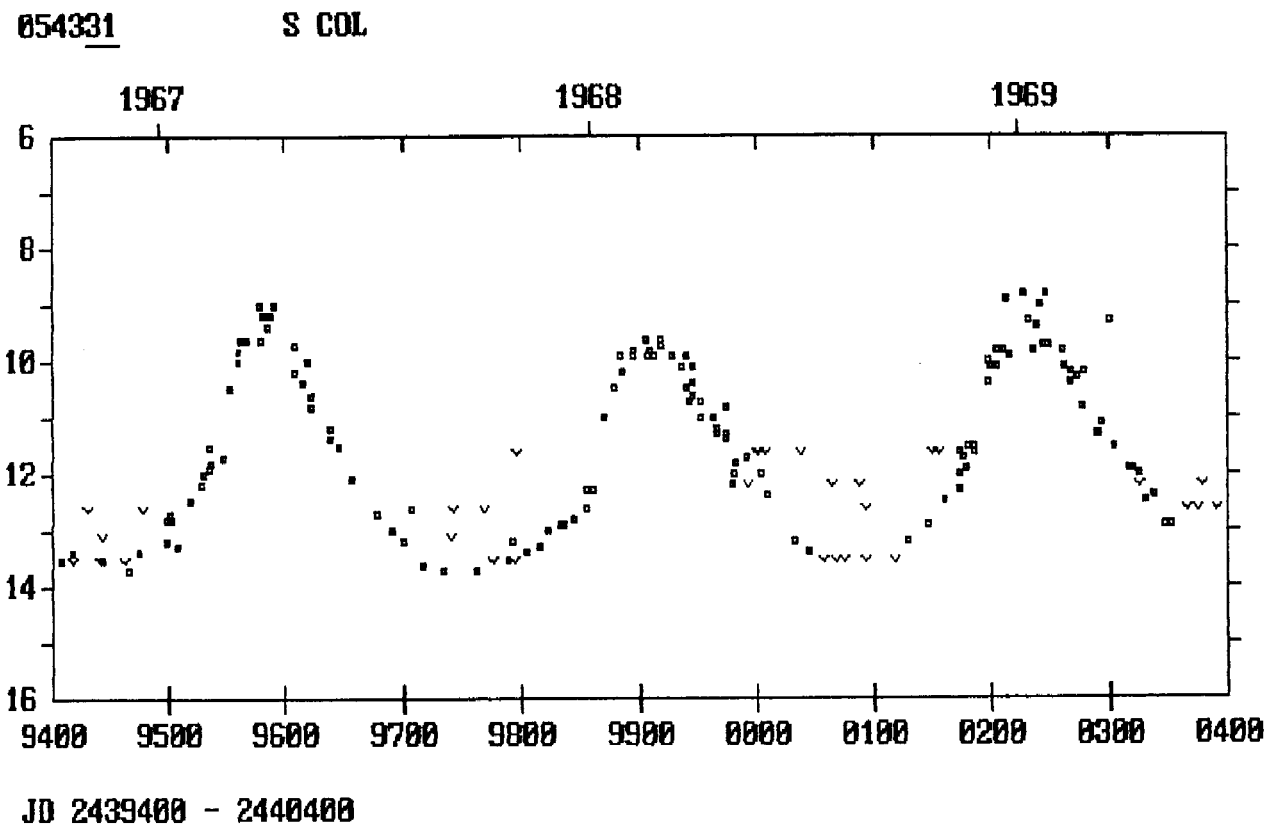



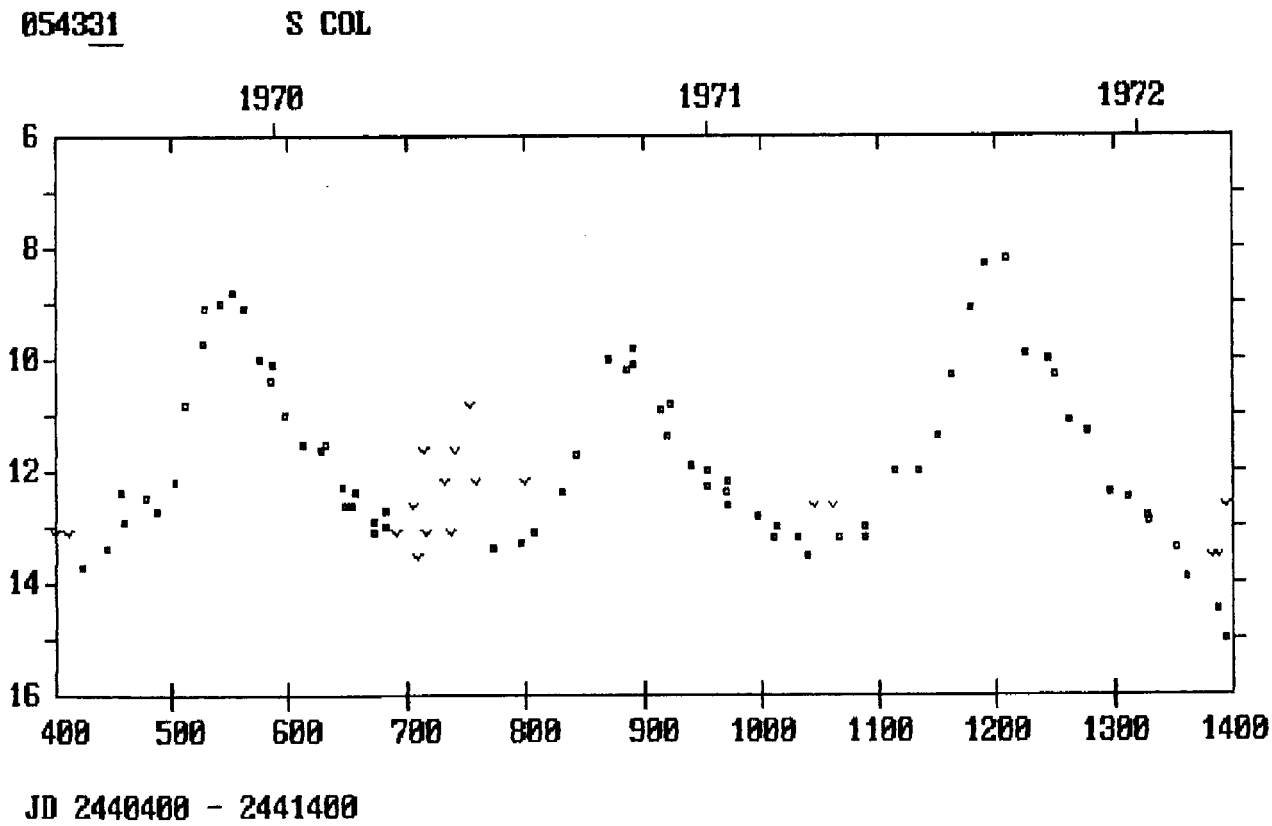

S COL

FIGURE 4

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,437,400 - J.D. 2,439,400



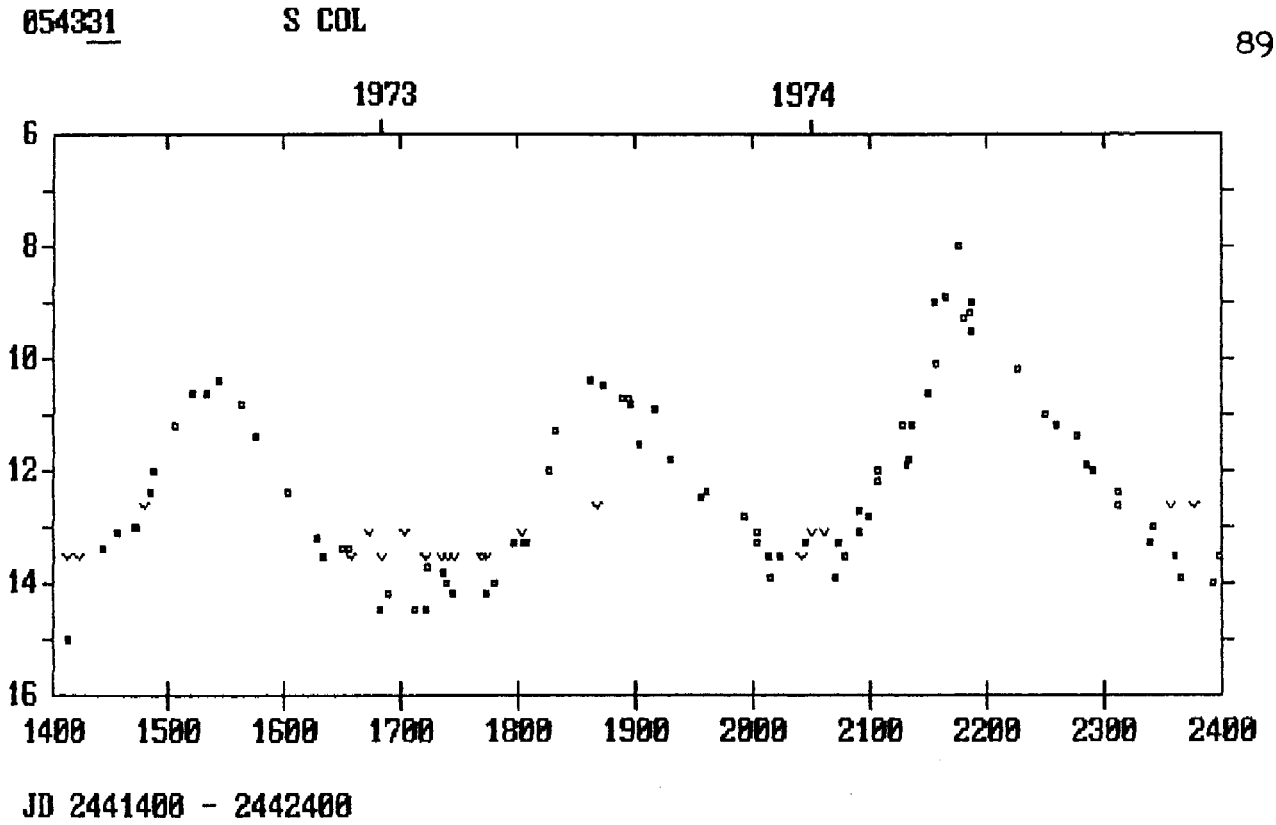



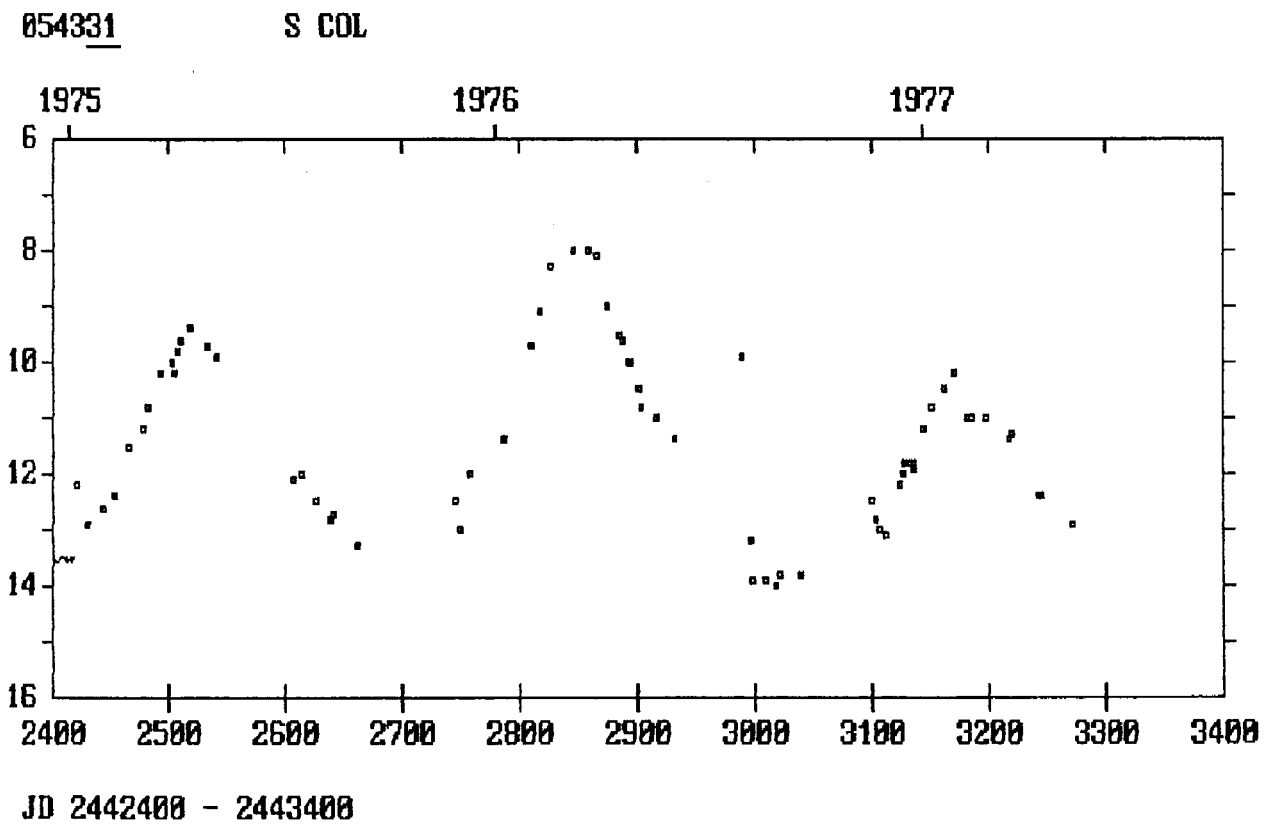

S COL

FIGURE 5

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,439,400 - J.D. 2,441,400



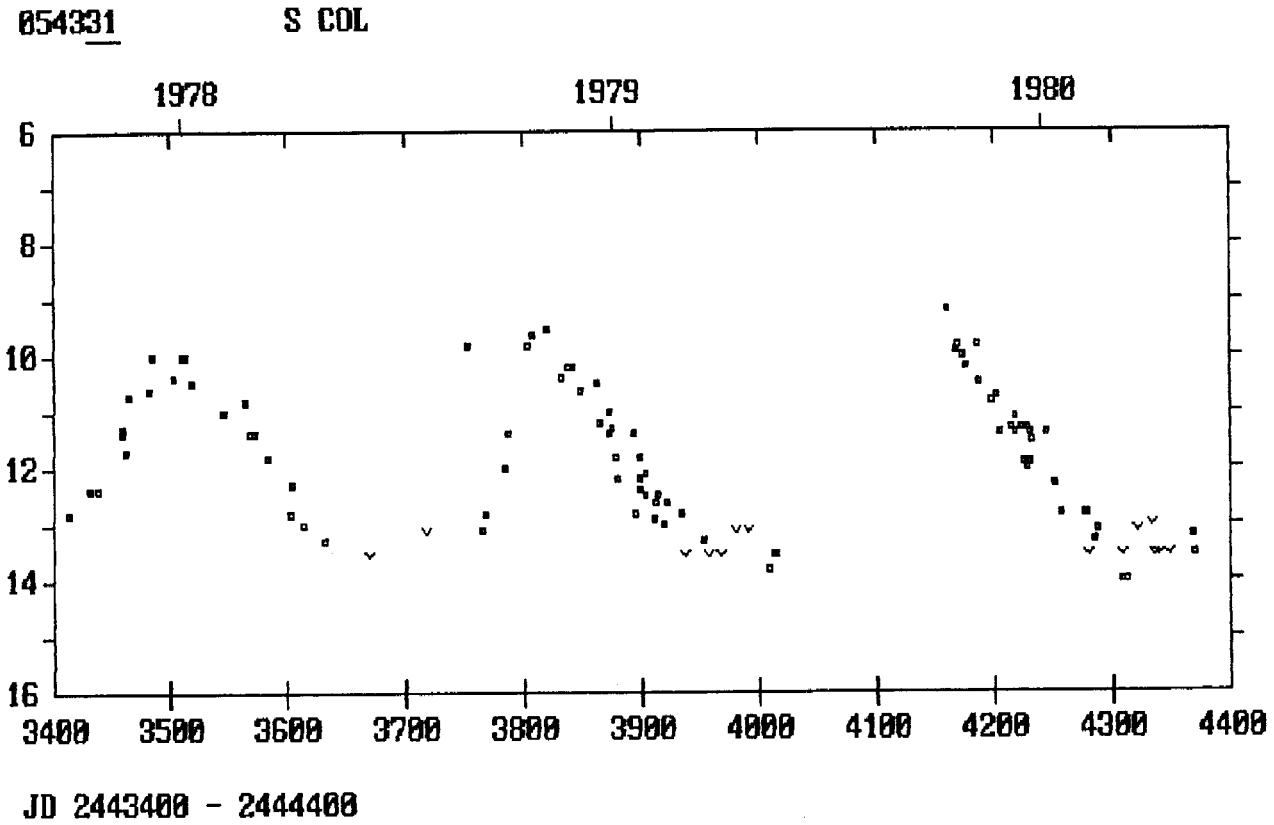



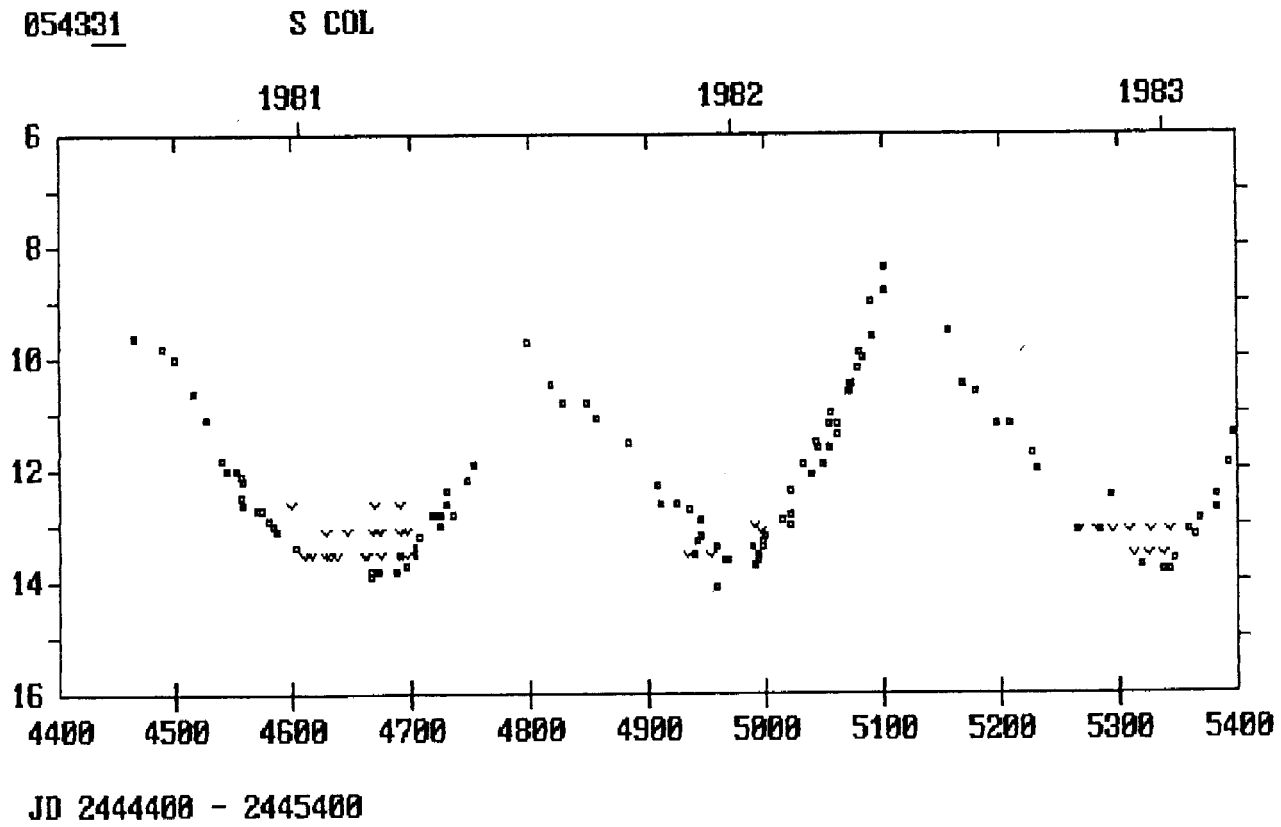

S COL

FIGURE 6

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,441,400 - J.D. 2,443,400




S COL

FIGURE 7

LIGHT CURVE FROM INDIVIDUAL OBSERVATIONS

J.D. 2,443,400 - J.D. 2,445,400

# REPORT OF THE VARIABLE STAR SECTION
# ROYAL ASTRONOMICAL SOCIETY OF NEW ZEALAND

## FOR YEAR ENDED 31st DECEMBER 1993

1. OBSERVATIONS: 66,293 exclusive of several thousand observations of non-programme stars. The reason for non-inclusion of totals for non-programme stars is that the computer programme was set up to total the estimates of programme stars. Individual totals for each observer appears at the end of this report with the final page showing the monthly distribution. This diagram reflects the normal seasonal trends with lower totals in the short summer nights and during the poor changeable spring weather. All totals are as usual for the year ended 31 August to provide strict comparison with previous years.

   Albert Jones and Danie Overbeek, as usual, made outstanding contributions with six other observers with over 1,000 estimates. However, all contributions whether large or few are valuable and have been fully used.

2. REQUESTS FROM PROFESSIONALS

   Numerous requests were made by professionals for our data on a wide range of stars. The following examples will show observers that their observations are both valuable and useful. In addition a number of special programmes were carried out at the request of our professional colleagues. All requests for results of decades of data were filled within a fortnight of receipt and supplied on floppy disks and computer light curves. This prompt service was made possible by the invaluable work of Ranald McIntosh.

   OY Car Barbara Hassall and Tim Naylor (U.K.) received prompt alert notice of a super outburst to permit their obtaining data with IUE. A light curve and print out of observations were supplied after the event.

   Z Cha All observations of this dwarf nova made by the Section over almost five decades were supplied to E.M. Schlegel (U.S.A.).

   WW Ceti Investigators at the Universities of Sussex and Keele (U.K.) are co-operating on an investigation of this dwarf nova for which purpose they received all our data and copies of the papers on WW Ceti that have appeared in our publications.

   TY Col This star has short nova-like outbursts as well as variations at minimum. C. Helier (U.K. & U.S.A.) was supplied with observations almost entirely made by Albert Jones. This programme continues and members with telescopes having thresholds of 14.0 are asked to pay more attention to this fascinating object.

   ETA & AG Car R. Viotti (Italy) obtained our published light curve of Eta Car and a preliminary one for the recent rise of AG Car. These were requested for the continuing investigation

into the S Dor type variables. The full light curve for AG Car appears elsewhere in this publication.

R.S.T & TY CrA Light curves of these pre-main sequence variables were sent to John Graham (U.S.A.) for use with his spectroscopic observations obtained in Chile.

VW Hyi J. Cannizzo (U.S.A.) obtained all our data covering almost five decades for his proposed detailed investigation of this well known dwarf nova. He was also supplied with a copy of Bateson's Memoir on VW Hyi.

C. La Dous (Spain) was given permission to reproduce some figures from the VW Hyi Memoir in a review article to appear in a book on C.Vs.

A light curve and details of observations of outbursts and an interval at minimum were supplied to Tim Naylor (U.K.) as part of a programme run at his request.

SY Mus C. Pereira (Switzerland) is investigating this Z And variable for which he obtained all our data.

NOVAE Hilmar W. Duerbeck (Germany) was supplied with our light curves and observations of:
Nova Sco 1989; Nova Dor 1992 ( = LMC Nova 1992 );
Nova Sgr 1992 No. 2 ( = V4169 Sgr); Nova Ser 1993 ( = MU Ser).
MU Ser is suspected by Duerbeck to be a recurrent nova. Members are requested to join Albert Jones in monitoring this star in case it has another outburst. Details of our database were also supplied to Duerbeck for inclusion in an article.

RECURRENT NOVAE The long term programme of monitoring stars of this type continued.

DWARF NOVAE IN THE GALACTIC HALO This long term programme with Steve Howell continued. Alert notices of several outbursts were sent to Howell as well as details of all observed outbursts of AH Eri which are summarised in a paper in this publication.

R CrB Variables Another long term programme which continued throughout the year. As a result a number of alert notices were sent to S.A.A.O.

WZ Sge type C.V.s Ronald Memickent (Chile), a graduate working under the supervision of Nikolaus Vogt, was supplied with observations of the southern examples of this group.

In addition to the above we received several enquiries for photoelectric programmes which were turned over to the Photometry Section. We continued to send the B.A.A. (U.K.) Variable Section copies of our data on Northern stars in which they are interested.

## 3. COMPUTER DATA PROCESSING

Don Brunt has steadily continued the processing of the hand written records prior to 2 April 1987, after which all observations were recorded by computer. To date Don has

processed 342,448 observations of 121 variables. This splendid assistance by Don has enabled Ranald McIntosh to add these to the computer data base.

Ranald has then provided the resultant light curves and print outs. Many of these light curves appear in this issue.

Ranald has continued to provide the print outs from which the Monthly Circulars are compiled. In addition to his excellent work in this area Ranald has also supplied the light curves requested by professionals. He also ran off the records on floppy disks whenever professionals asked for data covering many decades involving hundreds of thousands of estimates.

In the previous report reference was made to La Trobe University providing storage for our database after the data had been published. This arrangement fell through after Tom Richards left the University to go into business. It, therefore, remains one of our major concerns as our database is rapidly reaching full capacity.

4. PUBLICATIONS

Publications No. 18 was distributed during the year. No. 19 is currently under production.

5. CIRCULARS

Issues consisted of the usual 12 Monthly Circulars, Two Special Circulars and four issues of "CHANGING TRENDS". Prompt advice on Novae and other unusual events were distributed by Fax or airmail to observers.

6. "THE OBSERVATION OF VARIABLE STARS"

It was reported in the previous Annual Report that the 4th edition of this guide to observing has sold out. Members were invited to make suggestions for the Fifth edition. Their comments are appreciated, especially those from Peter Skilton. It is intended that the next edition be considerable enlarged which means that it is uncertain whether it will be available in 1994 or 1995 as there is a great deal of writing to be completed.

7. FINANCIAL

The New Zealand Government reorganised scientific institutions throughout the country. Astronomical Research Limited, a non profit private company, has since 1979 provided the finances that permit the Section to operate. The Royal Society of New Zealand recommended that certain changes should be made to the Articles and Memorandum of Association of Astronomical Research Ltd. to conform to the new economic climate. These changes involved much time and expense but our Solicitors completed the formalities towards the end of the year and have now obtained the necessary certificate registering the changes.

I extend my appreciation to Mr. Moore, Chief Executive Officer of the Royal Society of New Zealand, for his guidance and helpful suggestions.

Appreciation is expressed to the following for donations received in the 1993 financial year: Akira Fujii, P. Camilleri, Sue Dreves, B. Hassell, G. Herdman, P. Skilton, N.W. Taylor.

## 8. HEADQUARTERS

Close co-operation has continued with the leaders of the Variable Star Section, Astronomical Society of Southern Africa and the various Australian Societies. These sections are mainly responsible for the increase in the number of observers, especially due to the active encouragement of Jan Hers, Sue Dreves, Fraser Farrell, Peter Nelson & Peter Williams

The massive volume of correspondence continued to increase relieved to some extent by the wide use of fax messages.

It has been possible to employ Maureen Phizacklea as part time Secretary for most of the year. Her excellent assistance has taken the burden of much of the routine work off my shoulders. She now has also gained the practical experience to handle all problems any time I am away. Maureen has summed up her diverse duties in commenting, "I never know what will happen next."

My main tasks during the year apart from preparing issues of the Publications has included writing guide lines for those members who are assisting in the reduction of data on Mira variables; slowly drafting the outline and articles to appear in the fifth edition of, "The Observation of Variable Stars". In addition keeping Don Brunt supplied with archival records to process which often involves checking these records before sending them off.

I have recently commenced work in conjunction with Nikolaus Vogt on a detailed study of a large group of C.Vs. I have continued to provide graduates in several countries with basic observational data for their thesis. Filling the requests from professionals also has required much detailed work at times.

## 9. ACKNOWLEDGEMENTS

The Section belongs to our observers and without their accurate and painstaking observations it would not exist. My sincere appreciation is extended to all observers for their estimates, support and friendship. Earlier in this report I have mentioned the invaluable work and support from Ranald McIntosh, Don Brunt and the leaders of the Variable Star Sections in South Africa and local Australian Societies. To them all I am deeply indebted for their splendid assistance which has enabled the Section to run smoothly.

Mati Morel has continued to speedily produce charts for novae and other unusual variables. His work always reflects the high standards that have become a hallmark of anything he does.

Alan Gilmore and Pam Kilmartin have continued to provide magnitudes for a number of sequences whenever their duties at Mt. John University Observatory - and the weather - permits. The Section would be the poorer without their support and personal friendship.

Dick Hull, as always, has supplied the Julian Date Calendar which was included in an issue of "CHANGING TRENDS".

The cheerfulness and efficiency of Maureen Phizacklea has been of immense benefit to the Section. I extend my personal thanks to her not only for relieving me of much routine work but for the manner in which she handles a wide assortment of duties and for so pleasantly putting up with the vagaries of her Boss.

Finally I wish to thank all members and supporters, both amateur and professional, for their continued assistance and encouragement.

Frank M. Bateson
DIRECTOR

1994 January 31

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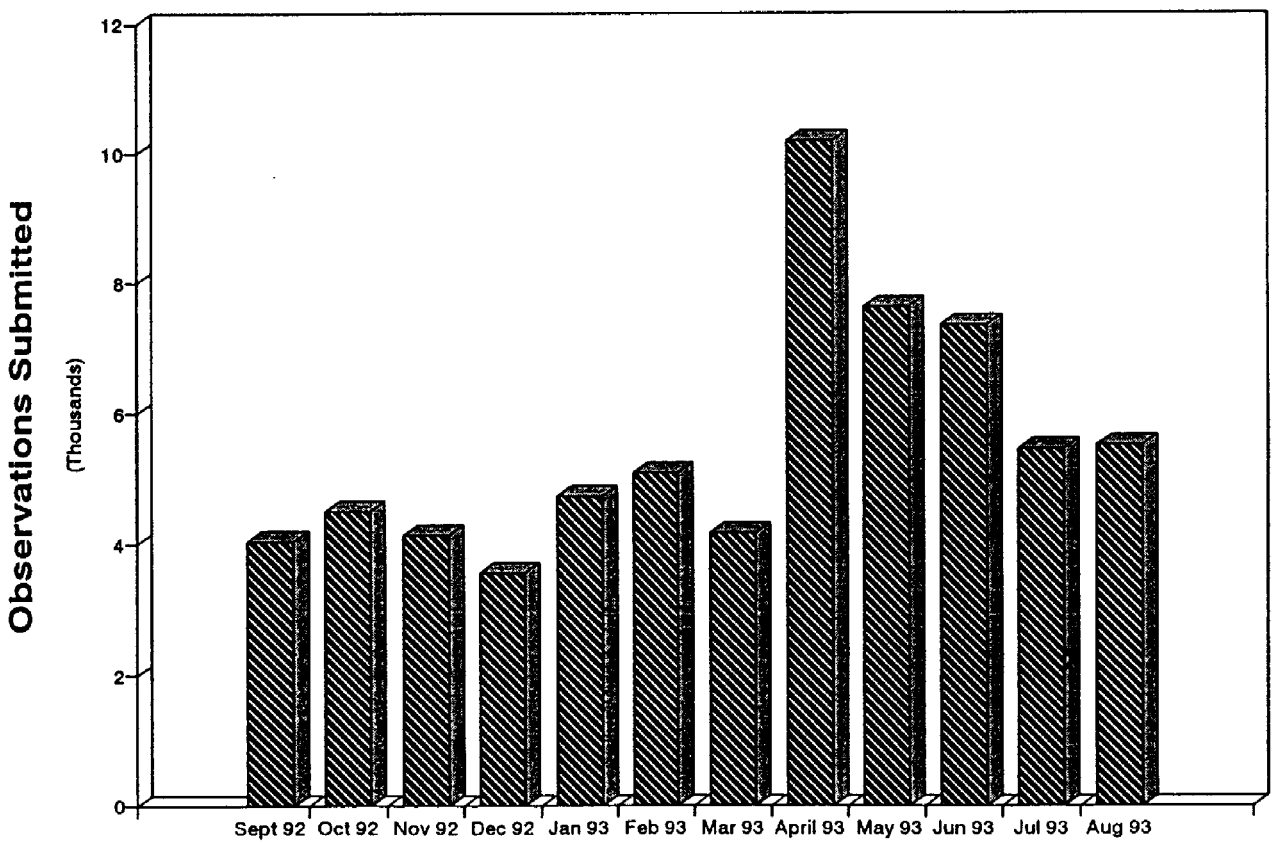
**Variable Star Section Observations**
**1992/93**



## VSS OBSERVATIONS RECEIVED FOR YEAR ENDED 1993 AUGUST 31

| OBSERVER | | OBS. CODE | OBS. TOTAL | OBSERVER | | OBS. CODE | OBS. TOTAL |
|---|---|---|---|---|---|---|---|
| AUCKLAND OBS. | | AO | 26 | MURRAY | A.M. | MG | 199 |
| ALBRECHT | W.M.B. | Aj | 4078 | MORAND | L. | MIA | 887 |
| BALL | S. | BB | 7 | MATTIAZZO | M. | MKA | 329 |
| BRANDIE | J. | BD | 738 | MENZIES | B. | Mf | 685 |
| BURNS | G. | BE | 17 | MOREL | M. | Mv | 8 |
| BAADE | W.H. | BH | 8 | NELSON | P. | Nl | 877 |
| BRADBROOK | A.J. | BK | 21 | NATION | P. | Nn | 127 |
| BOATTINI | A. | BS | 111 | O´KANE | J. | Ok | 174 |
| BRYANT | K. | Bk | 13 | OVERBEEK | M.D. | Ov | 15824 |
| BLANE | D. | Bz | 514 | PARK | J. | Pj | 8 |
| COOPER | T. | CH | 397 | ROBINSON | N. | RB | 186 |
| CAMILLERI | P. | CM | 70 | RICHARDS | T. | Ri | 102 |
| CRAGG | T.A. | Cj | 3215 | STEPHANOPOULOS | G. | SK | 50 |
| DREYER | N.J.G. | DA | 3 | SMIT | J.A. | SP | 1064 |
| DREVES | S. | Dx | 845 | SAW | A.D.J. | ST | 190 |
| FARRELL | F. | Fm | 798 | SKILTON | P. | SU | 1077 |
| GRIFFITHS | B. | GA | 8 | TUCKER | P. | TA | 8 |
| GARLAND | B. | GB | 70 | TURNER | D. | Tq | 21 |
| GOLTZ | W. | Gp | 4607 | TREGASKIS | T.B. | Tr | 411 |
| HERDMAN | G. | HA | 1736 | TAYLOR | N.W. | Ty | 2272 |
| HERNSHAW | C. | HH | 571 | TILBROOK | J. | Tz | 439 |
| HULJAK | J. | HJ | 46 | de VILLIERS, | S. | Vb | 67 |
| HARRIES-HARRIS, | E. | Hi | 831 | VENIMORE | C.W. | Ve | 9 |
| HULL | O.R. | Hl | 1523 | VAN BLOMMESTEIN, | P. | Vn | 2 |
| HERS | J. | Hz | 536 | WARD | W. | WD | 14 |
| INGRASSIA | P.A. | In | 58 | WATSON | D. | WJ | 345 |
| IVES | F. | Iv | 560 | WADHWA | S.S. | WM | 71 |
| JOOSTE | J.L. | Jf | 32 | WALSH | S. | WP | 170 |
| JONES | R.W. | Jg | 2444 | WILLIAMSON | L.J. | Wm | 457 |
| JONES | A.F. | Jo | 16730 | WARD | R. | Wr | 43 |
| KENT | K.E. | Kn | 133 | WINNETT | R.D. | Wu | 58 |
| LUMLEY | E. | Lm | 292 | WILLIAMS | P. | Wy | 3154 |
| | | | | | | TOTAL | 66293 |