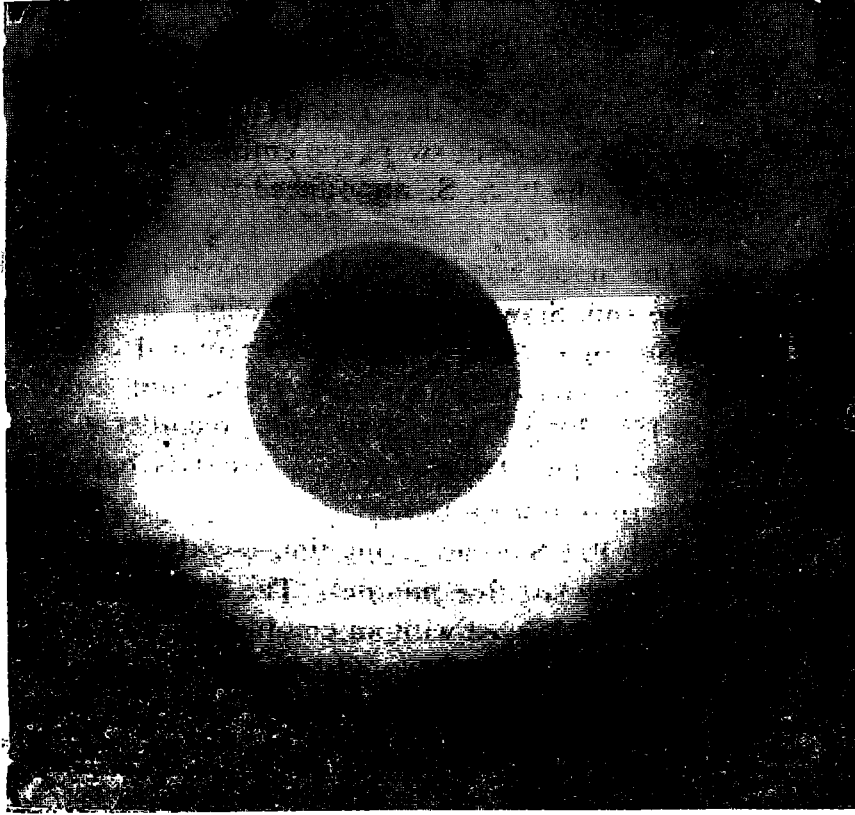


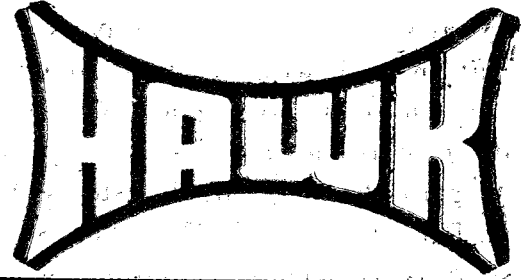
# THE DAY OF THE DARK SUN

By Ramesh Chander Kapoor

In this issue, the *Hawk* takes the pleasure to bring on record first-hand impressions of some distinguished scientists of the Indian Institute of Astrophysics, Bangalore, the only research institution of its kind in the country, about the great astronomical event of the century, the Feb. 16, 1980 Total Solar Eclipse.



The Eclipsed Sun photographed by Dr. Nedungadi, using a 400 mm telephoto lens.



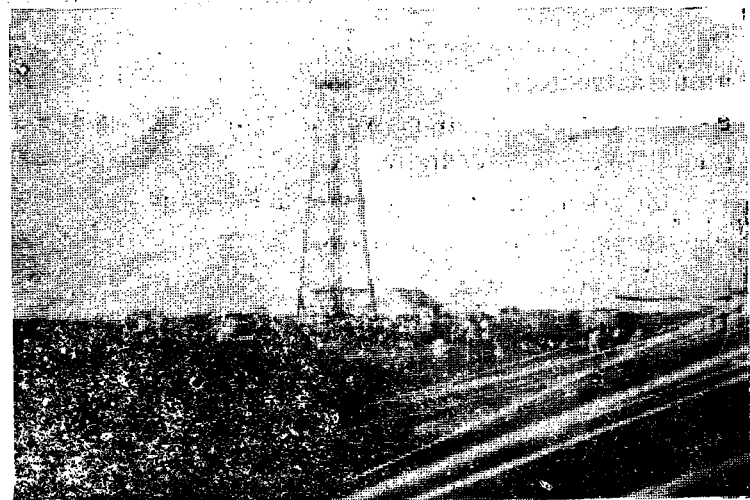
Rainbow

*The success of the marriage comes after failure of honeymoon.*

—Chesterton

**T**HE DAWN of the 16 of February, 1980. It was beautiful. Activity at the Camp had begun even before the brilliant disk of the sun rose above the horizon. For the past few days, life had been quite hectic despite persistent appearance of clouds which had been going on for nearly the whole fortnight when the Camp was being set up. The previous day itself thick clouds had romped around in the sky as if to tease us mortals. The ordeal seemed to be over when the day broke with a crystal-

clear sky save for a trace of clouds near the horizon; but it vanished soon. The astronomers, many of whom had slept for an hour or two, began giving a final touch to the preparations that had gone on for several months and been planned much earlier. At 15<sup>h</sup> 42<sup>m</sup> 46<sup>s</sup>, the disk of the moon was to fully cover that of the sun when the outermost layers of its boisterously hot atmosphere (called chromosphere and corona) would shine with a grandeur unsurpassed, letting us carry out observations otherwise not possible from the ground. The area where the equipment were set up had been cordoned off lest at crucial moments, crowds gathering in the 3-acre expanse of the Camp disturb what we intended to do. Thanks to the keen interest evinced by the Fourth Estate in the Eclipse and our concern with it, the Central State Farm, a place



The 68-foot tower, the major attraction of the East Camp of I.I.A. at the Central State Farm, Jawalgera is surrounded with several experimental setups of the teams of scientists from home and abroad. Photograph by Ashok Pati.

## The National Mood

The Madame Above All



त्वमेव माता च पिता त्वमेव,  
त्वमेव बन्धुश्च सखा त्वमेव ।  
त्वमेव विद्या द्रविणं त्वमेव,  
त्वमेव सर्वं मम देव-देवा ॥

[ Hey Goddess (of India)! Listen. (Our parents having kicked us out for being unemployed,) It is you who is our mother and father, (our friends having deserted us for lack of money,) it is none other than you who is our friend and the closest friend; (you being the first-rate manipulator as one is supposed to be to deal with this shrewd world,) you're our (curriculum of) learning; and, (as our wealth has been confiscated by the Establishment for the 'national cause' in view of the constitutional amendments ushered in by you,) it's you who's our wealth. (In fact.) You're our all-in-all. ]

*Ramesh Chander Kapoor*

about 11 kms away from a small town Jawalgera in the Raichur district of Karnataka where we had set up our Camp, became known throughout the country. Hence, crowds which we wished to avoid arrived not in twos and threes but in busloads.

What was the great idea of setting up another I. I. A. at such a god-forsaken place, far away from civilization and with minimal amenities? Taking tons of equipment to a place 421 kms from the Head Office at Bangalore was no joke. Bangalore was to get only 92% of the sun covered by the moon. Partial eclipse as it is called is hardly of interest to us. It's the total eclipse of the sun that, reveals for once a treasure of information contained in its chromosphere and corona, and that too for a few minutes only. Not that solar eclipses are rare; they take place time and again. The problem is that more often than not, the places where the path of totality falls are either inaccessible or the weather is bad. Scientists are further thwarted from their goal by equipment failure; or, even men behind the instruments might not open the 'shutters' at the right time. And that is very important.

The path of totality for the 1980 eclipse fell close to places in India from Hubli, Hospet, Raichur and Nalgonda to Konark. Having made an elaborate study of the meteorological data of the past one hundred years for the eastern regions of the path of totality, we finally chose two places to establish our observatories, one at Hosur near Hubli and the other near Jawalgera. The latter became a greater attraction to newsmen, film-makers and commoners alike where we had built a massive all-steel tower, 68-feet high. An optical system consisting of coelostat and a lens placed atop the tower was to send the image of the 'eclipsed sun' to its bottom, converted into a basement laboratory with thatched walls. Here we had installed a sophisticated instrument, flash spectrograph to be precise, in order to analyse the chromospheric and coronal radiation. Working 18 hours a day, braving the heat of the sun, our men had taken nearly two weeks to erect the tower and we were afraid whether the weak black cotton soil of the region would be able to take its weight. It did not sink. All in all, there were seven experiments to be conducted. Camping with us were Czech and Yugoslav teams which set up experiments of their own. The Czechs had brought their equipment from Czechoslovakia in a caravan of cars and trucks via Iran and Pakistan in 25 days. Unable to stand even the February Sun of Northern Karnataka, they moved around in the Camp only in their shorts.

There were several guest scientists too at the Camp to witness the great event. The most distinguished among them were Profs Trehan, Narasimhan & Bart Bok (University of Arizona). Bok despite his 75 years had braved the tiresome travel and heat just to watch the eclipse. A public

address system (P.A.S.) had been installed near the tower through which a colleague of ours was to announce the progress of the eclipse. He had his instructions and timings of the eclipse scribbled on a pad. Everyone at the Camp had been given dark negative film pieces lest retina be damaged while looking at the partially eclipsed sun. The negatives won't be needed during totality. As the hour drew near, everyone at the Camp became restive. A wave of excitement swept the entire Camp when at 14<sup>h</sup> 24<sup>m</sup>, the P. A. S. announced that first contact had been seen.

The moon was progressively covering the disk of the sun. Slowly we began feeling the ambient temperature falling. Tension mounted sky-high when the sun became an incredibly thin crescent. At 15<sup>h</sup> 30<sup>m</sup>, I placed a tape recorder near the basement hut. The following account is based on a transcription from it.

The P.A.S. began giving time counts every minute during the last five minutes. The announcer's own voice was charged with an emotion that dramatized the whole event. Soon we heard the announcement.

"All the observers note that time is only two minutes to the second contact ... : FIVE, FOUR, THREE, TWO, ONE, MARK" The surroundings had become pearly blue; someone in the distance shouted "Shadow bands!". A technician inside the tower basement hut hollered 'Ladder, Ladder!' while the P.A.S. began :

### What a Corona !

At 15<sup>h</sup> 50<sup>m</sup>, Bappu came out of the basement hut. He looked tired, but with a gleam of contentment on his face. He had to struggle for words when he began recounting his experience. "Hah ! What a corona ! ... The whole blasted thing was so short ! ... Being a solar maximum year, one expected that the corona would be quite symmetrical and it certainly was. So many beautiful streamers ! Prof. Bok says he has seen diamond rings that last for a longer duration... This, I am sure, was about five seconds... Breathtaking ! I only wished the eclipse lasted a little bit longer. But that is what is the principal charm of the eclipses !!"

*(From A Tape Recording)*

'EVERY SECOND WILL BE ANNOUNCED DURING THE LAST MINUTE. COUNTS WILL BE STOPPED FIFTEEN SECONDS BEFORE SECOND CONTACT. I REPEAT, COUNTS WILL STOP FIFTEEN SECONDS BEFORE CONTACT. COUNTS WILL START AGAIN AFTER ANNOUNCEMENT OF FLASH. DURATION OF TOTALITY IS ONE SIX FOUR SECONDS'.

Dr Bappu, Director of our Institute, who was heading the observers' team stood inside the basement hut not in vain. Holding a monocular with a transmission grating (which like a prism disperses

the sunlight in seven colours of the rainbow called spectrum) ahead of it he was looking at the eclipsed sun. He would announce the beginning of totality as soon as he saw dark lines in the spectrum of the sun change over to bright ones. This is called the flash spectrum of the chromosphere which normally cannot be observed. The beginning of flash marks the beginning of totality.

Everyone by the side of his equipment, ears glued to the speaker. Eventually, the announcement came:

"SECONDS CALLS FOR LAST MINUTE STARTS: SIXTY, FIFTYNINE, FIFTYEIGHT, FIFTYSEVEN..... TWENTY, NINETEEN, EIGHTEEN, †SIXTEEN, FIFTEEN!"

An ominous silence followed. Hearts beat faster. Those fifteen seconds we were all motionless, till Bappu in a loud but bass voice announced 'FLASH.' As if all the observers came back to life. Observations began, cameras clicked and hundreds of spectators turned their heads upwards. Overwhelmed with the beauty of the corona that no words can describe and no camera work can reproduce, they clapped, shrieked and cheered with rapture.

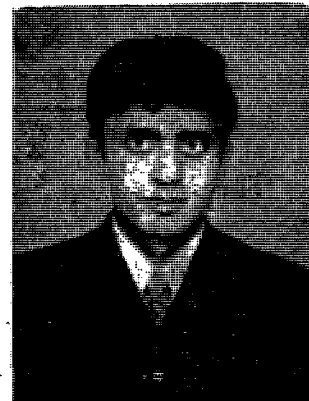
Seven seconds after the flash, counts began again, EIGHT, NINE..... Somewhere a woman moaned overcome with joy..... TEN, ELEVEN, TWELVE..... Observers did not know what others were doing. Feverishly they went about their work. Somewhere, an observer asked the other, 'Shall I open the shutter?' Elsewhere, the film in the movie camera of a team of film makers got stuck up. They opened up their cameras, worried for some time but got over their problem soon and went ahead with shooting the sun. That was not a Sun we had seen before. The disk was fully covered by the moon. What met the eye was a dark spot surrounded with beautiful bluish streamers of incandescent gas extending to several solar radii in all directions. It was fairly symmetrical because of the sunspot maximum, a time when the sun is most 'active'. The sky was not as dark as we had thought it would be. Despite a sky quite brighter than in the full moon night, it was easy to spot the planets Mercury and Venus. Spellbound the people looked at the innocent beauty up there, forgetting everything for once.

The show was coming to a close. The progressive counting made us all the more tense: ONE FIFTY-NINE, ONE SIXTY, ONE SIXTY-ONE, ONE SIX TWO, ONE SIX THREE, ONE SIX FOUR, ONE SIX FIVE, ONE SIX SIX ..... and lo! there leaked rays of the sun through a huge valley on the moon. Progressively sparkling up at one end and like a thin crescent in the rest, the disk of the sun appeared like a beautiful diamond ring, a most fitting parting gift to us mortals from

† The count 'Seventeen' was missed in the announcement.

up there. The crowds in an all the louder tone cheered the sun at the sight which lasted hardly five seconds. The beautiful corona submerged in the intense light of the sun and with this the grand show was over. Counts went on until 300.

People jumped, shook hands, congratulated each other and some even danced. Everybody was talking excitedly and in their excitement, lots of people entered the cordoned off area unknowingly disturbing the setup where some observations were still going on. Nobody now



RAMESH

### What is a solar eclipse?

A solar eclipse takes place when the moon in the course of its movement round the earth comes exactly in between the sun and the earth. The lunar orbit being inclined by about 5 degrees to the plane of the Earth's orbit cuts it at two points called the ascending node (where the moon passes from south of earth's orbit to north) and descending node (moon crossing earth's orbit, going south again) respectively. Thus rather than an eclipse of the sun occurring once in every 29.3 days at each new moon, it happens only at or near one of its nodes. The sunlight blocked by the moon casts narrow shadow comes behind it. The darkest shadow (umbra) is a converging cone. To an observer located in the umbra, the solar disk looks fully covered by the moon. A comparatively lighter shadow (penumbra) is a diverging cone and, therefore, much wider. To an observer located in the penumbra the sun looks partially covered. Earth's diurnal and annual motion combined with moon's orbital motions make the umbra move over the earth's surface along a curved track called *path of totality*. It starts at what we call the sunrise point (where the umbra first touches the earth's surface) and ends at the sunset point (where the umbra moves off the earth's surface). The beginning of the eclipse is called first contact when the disk of the moon has just touched the sun's.

Gradually the sun becomes a thin crescent. The shadow of the moon approaching from west a minute before it fully covers the sun presents an unforgettable spectacle and before he can realize, it sweeps past the observer at a speed of 800 meters a second, giving rise to a peculiar effect called 'shadow bands'. These are produced because of scintillation on the brilliant head-like points on the disappearing or reappearing crescent of the sun. These can be seen on a white wall or on white sheets spread on the ground. Second contact takes place when the moon fully covers the sun. This is the beginning of totality which at a given place generally lasts for a few minutes, the longest duration being 451 seconds. Third contact marks the end of totality and fourth contact that of the eclipse.

bothered to look at the gradual uncovering of the sun. The eclipse was over at 16<sup>n</sup> 54<sup>m</sup>.

Soon there followed a series of interviews of some of our colleagues. The experiments had gone on smoothly. We were happy. That evening became a memorable one. There was a camp fire at the Camp late in the evening. Talks, group songs and dances! A day of hectic activity had a joyful end.

### **The Sun**

The sun is a star, and an ordinary one from astronomical standards. A huge gaseous ball of 2 billion billion billion metric tons in mass and 14,000,00 kms in size, the sun is on the average 150 million kms away from us. By mass, 71 percent of the sun is hydrogen, 27 percent helium and 2 percent other elements. Its visible surface called photosphere (not a solid one) has a temperature of 6000° C and is sometimes seen with dark spots, called sunspots, which keep changing in number. The variation takes place over a period, on average, 11.1 years (the solar cycle). Above the photosphere lies a thin atmosphere of more rarefied gas (about 10,000 kms thick), known as chromosphere. In its lower part are produced the dark Fraunhofer lines of the sun's spectrum. This is surrounded by an extremely thin atmosphere of gas called corona. The corona extends out to several solar radii. Its density is less than one million millionth of that of the terrestrial atmosphere at the ground level, whereas its temperature reaches two million degrees centigrade. It can be seen during a total solar eclipse only as otherwise its feeble light is greatly suppressed by that from the photosphere.