Miss Reeves

X20593

draft

..... a little bit, my skin waswet and it didn't stick the way it had stuck when we tried it out in the trainer and in the capsule on the pad and I finally gave up on it and just kept one eye shut. This is marginally satisfactory, I guess, but I was not well nighted after coming up to the first night. There's a redundancy here but you sure do have the right information or cases so a few of these will be repeats. Now lets start out with the conditions of dark adaptation.

Well, most of these things that we had planned to look into if we could on Astronomy sort of went by the board, and I apologize to the people at the Cape that we didn't get mgr more (done) that we had planned to do but as I think most of you are aware, at the end of the first orbit we start, ea. having some difficulty with control system, and from then on it was pretty much systems monitoring with some looking around outside and that was it. So a lot of the things that we had planned to do and a lot of the things I had hoped to bring back just had to go down the drain, It About but becoming night adapted--the first time around I did get the eye patch out that we had and this was not a very satisfactory eye patch. I was going to try to use it over one eye so that I could become was night adapted. I was sweating a little bit, my skin was wet, it didn't stick the way it had stuck when we tried it out in the trainer and in the capsule on the pad, and I finally gave up on it and just kept one eye shut. This is marginally satisfactory I guess but I was not well night adapted coming up to the first night. What it boils down to is that my dark adaptation was just a result of the sun going down and not normal dark adaptation from being on red light and dim light, which takes some 10 to 15 minutes to get any

degree of adaptation out of. I could notice a difference in the numbers of stars I could see at first going last after the sun first went down and later on then compared to when I'd be well night adapted at the end of the period. This is some 37 minutes later when you're approaching sunrise so you'd have a -- I suppose there was a actual period there where you're really dark adapting of about a half hour, 33 minutes, something of that order.

Did you have an opportunity to count the stars?

No, this is one of those things that went down the drain. I thought about this on a subsequent orbit but I didn't spend any time on it. I feel that my vision, the numbers of stars I could see was not appreciably increased. Now, I had expected to see a lot more stars. I had thought they'd really jump out once you got above the atmosphere but I--like it was in debriefing - - - I think of the being out on the desert on a dark night in summer when the air is very clear and dry, and you know what it is like out around Reno and some of those places; how the sky really comes out at night and you can just see a million stars. and thats what it looked like. It didn't look like any more than that.

This was a general impression but not anything you can put your finger on?

Thats right.

You had planned at the end of the second and third orbits--during the second and third orbits to run the star counts and we had the areas lined up O-RI-AN, CAS-I-O-PIA, and what was the other one--it was off a little triangle area by SERIOUS off O-RI-AN. We had those three areas lined up and it was just--I was doing systems monitoring at that time rather than counting

stars. But a general impression of looking out at these areas was that the numbers of stars I could see was not greatly increased.

You mention the transmission through the glass be comparable ... to the atmosphere. That's something you people can check.?

That's right.

McDonald, through their studies of the window had felt that we probably would not see too many more stars because the transmission of light through the window is cut down by 27 per cent or something like that. The figure that they came up with was almost identical to what people have computed the atmospheric attenuation of light is. So they felt that when we got above the atmosphere it would probably be about the same looking through the window as it is looking through the atmosphere here, and I think they were just about right. It looked to be about the same to me.

I think it might be wise for you to read the next 3 or 4 paragraphs. I think a lot of these are going to be real quick answers, so why don't you get to it.

Did you see Magellanic Clouds? No. Andromeda Nebula? No. How much did the moonlight affect your ability to see faint surface areas?

Tremendously. We had moon out--almost full moon. You can look at this two ways, it was a tremendous disadvantage or it was a tremendous advantage. I prefer to think it was an advantage because it did provide a visual capability on the clouds--on the dark side which was sufficient that I could use it for a new reference where it might have been questionable whether I could do that otherwise.

— Was this bothered or being bothered by moonlight on the windows or was the sky actually bright?

No. The sky was not bright. I didn't notice the sky being bright at all nor was it moonlight bothering on the window of the capsule. It was moonlight on the surface of the earth back from the clounds when I looked down that direction I could use as a Yaw reference.

→ Yes, but I heard you say that the moonlight very definitely did bother your ability to see faint areas. I'm trying to find out in what way.

Well I don't--perhaps that was a misstatement. I don't think it really hurt on seeing fainters I don't believe. I was thinking of the more complete night adaptation we would have without any moonlight at all. This is so slight you couldn't--I doubt if you could pinpoint [redacted] differences.

→ What about daytime stars?

Daytime stars I couldn't--if I was going along and looking down at the horizon, the area behind the capsule and would look up, I couldn't see any at all. But when we had the small end of the capsule up above the horizon and over to the right where it was shaded from the sun, then if I stayed in that position for, oh, anything over a minute, I guess, then I could see the brighter stars start coming out. I never remained in that position long [redacted] enough to become night adapted where I could identify constellations or pick out specific stars but I wanted to see whether we could pick up stars on the daylight side and you could after about I guess a minute adaptation.

→ Perhaps we had better move on then to the question of stars very near the moon.

This didn't seem to be any problem. Looking up fairly close to the moon, I would guess a--counting a number degrees probably, you could see right up to the edge of the moon. The stars would be visible right up--very close, its not like it is when-[you observe the moon from the earth's surface]

→ Fairly faint stars?

Yes, I think so, just like the other--the whole field of stars you're looking at, you come up and--the only way, when you swing the capsule around and you'd be approaching ~~XXXX~~ area where the moon was, you could tell it because there would be moonlight coming in the window and you would see the light moving across on the capsule. ~~XXXX~~ Thats the only way you would know that you're really coming close to the moon. You didn't know it by the sky getting ~~X~~ real light as you come to the moon like you do here. There was a little area around it where this was true. It wasn't just a complete cutoff, but it was nothing like the buildup we have here where you are looking through the atmosphere and get all this.[scattering].

→ Any Comets?

No. No comets. I used the first sunset. I had this little polaroid filter out were were going to use so that we could look directly at the sun. This, while I think of it, this was another thing that was rather surprising to me. The sun is not as blinding as I thought it would be. I told the people in debriefing down there after experimenting very carefully with this a little bit, I looked directly at the sun with the naked eye just as you would do here. You've looked up and squinted so that you have really shielded your eyes and looked directly a t the sun and a little sliver of light through. And

this was very similar. You do the same thing there and I had no--there was no problem with the eyes. The light though, it was very noticable. The light was a very brilliant clear, white light and what it looked like coming in the window and the way it looked on the suit--the best thing I could relate it to were the arc lights, the brilliant search light arc lights that they have down at the Cape that are out on the pad at night. Its that type brilliant white light coming in--very bright. And it was warm enough that I remember commenting, I put it on the tape I believe at one time that riding along the sun was coming in and it was over on my right arm and I commented about my right arm getting appreciably warmer than the left when the sun was on it. It was a very intense light but as it came in the window and was on your arm here thats just what it looked like. It looked like being on the pad at night with these real bright search lights on. Same type light, it wasn't any of the orange-ish yellowish light.

....(Inaudible)..... in size from the UV?

Oh, yes.

This is the difference.

Any unanticipated celestial features?

The comets I--to get back to comehs here a minute--I guess we didn't completely cover that one. See any comets? No. Not at all. When the sun goes down its a--well this was a very brilliant brilliant thing and the light was spread out much more in a much broader band out toward the horizons than I had anticipated. I had thought--I don't know why, no one had ever briefed me on this particularly--I thought the sun down. It would be a little bit of light right on the ..... and bang, thats it. There are nothing but stars

from there on. Thats what I was prepared to see, I guess, but this wasn't the way it was at all. The sun goes down and its a brilliant display. Theres all the spectrum lined up here almost. Just as the sun goes down--well before the sun goes down you have a broad band ..... down in the atmosphere that we show on the pictures that I took too and I'm sorry we don't have those here to brief you with those but you'll see those later where starting with the sun down on the horizon there a great band that runs way out here maybe I think I estimated some 45 to 60 degrees on each side of the sun, way out. And it gradually ~~gat~~ goes down to a point out here like that. Starting from a very bright white band close to the earth and going out to a point out here and the other bands of light going from, oh, yellowish and orange color on up into the blues as you get off toward the black of space. Just as the sun sets that last little sliver of light where I was looking for the green flash that everyone has been looking for, that I had been briefed on, just as I'm watching for that, just as the sun gets down on the horizon, why it joins this long sliver. So you don't actually see that last little sliver of sun. It goes down, you can tell when it goes down but its not a clear ball just going below the horizon like that. Its out in this broad sliver that goes out toward the horizon.

This band is primarily a horizon phenomena. It doesn't run _____ ~~perpendicular~~ perpendicular wise?

No. Its in the atmosphere. Very definitely.

Its shows it quite well on that photograph there.

The zodiacal light I looked for and I never was night adapted enough to see it.

Solar Corona?

Solar Corona. No. This--once again I think to observe these things properly we are going to have to be night adapted before we get there and thats what we lost by having other complications on the second _____.

To get back to the unanticipated celestial features.

Well, unanticipated celestial features--the little light spots, luminous spots that I saw--I don't think these are celestial features. I don't know what they are. Can we get back to that later?

Uh huh.

I think unanticipated celestial features, another one to do with sunset is that the sunset lasted--the lightness much longer than I had anticipated. This went on for some 4 or 5 minutes that you could still see bright bands and ~~thing~~ then they would gradually go to a more dim condition but this occurred--this was over some quite ~~lengthy~~ lengthy period of time--about 5 minutes. I had expected the light to just go down very shortly after sunset. But it didn't, it was quite brilliant, quite bright for a long period of time.

Would you concentrate on _____. It would be a concentration over the horizon but were there many _____?

No. Another unanticipated celestial thing at night though was this cloud that I described, the haze layer or whatever it is. I notice this at first because as the stars were coming down toward the horizon they move rather rapidly down toward the horizon at first. I was watching one particular star and it got rather dim and I thought well its going behind the horizon and then it got brighter again as it came down closer to the horizon and then went out of sight. Well then when I looked very carefully I could see here is a band that was some--I think we estimated about 6 to 8 degrees above the horizon and was

probably a degree and a half to two degrees wide and it was quite visible once you start looking for it. It seemed to go out and taper out. No, it didn't taper as much as the light at the horizon did during sunset. It was more of a solid type band. It looked like the color of it would be sort of a buff--look like a buff light color--I don't know, something like this rather than a pure white, be sort of an off color, just not a pure white.

(Question by Dr. Roman inaudible)

No. All these things you see are things that we had planned to use at first orbit, mainly just hold position, get all the radar data, all the tracking, monitor systems closely and thats what we were doing and then we flew the first orbit then we were going to broaden this out a little bit on the second and third orbit and thats where we got trapped because the second and third orbit kept right on doing what we were doing on the first orbit.

We over time in Astronomy. Lets try to finish up real fast and come back _____ _____.

Any planets?

Yes. Venus, I believe it was--I identified it on the tape, on the chart. Wasn't it Venus that went down just above the _____ that particular day. Venus was very visible immediately after the sunset. The sun would go down. Just as quick as the last light was gone I could see that very clearly. In fact I believe on the tape I identified that before the sunset. I could see up that close to it.

(Statement by Dr. Roman, inaudible)

That will come up on the star chart that day. Yes, and we had them all plotted where they should be. You may be right. I'll have to check the chart on that. Venus and Mercury had been right--closer. We had them

identified by the previous shot. I think maybe this one Mercury. Lee ~~must~~ check the chart on it.

See any stars _____?

Zodical light. No. Solar Corona. No. I was not well enough adapted to _____ patterns along that line.

Shadow of earth of sky?

No.

To photograph the Orion region, it looked about the same as it does from the ground. This area in the center of the Orion that I was trying to use as a target area, the center star in the belt--we got several pictures of that. These were taken with different drift rates on the capsule. We tried to press the capsule on manual control and get it right on very accurately and ~~in~~ then use the camera but there was still some drift in the capsule at that time and I had to keep _____ for it. This is not a stable a platform as you would like for this type photography. Made exposures of about 15 to 18 seconds. I was counting off the seconds myself without explosion. Thats about it. I been interested though to see whether those came out. I did see some prints and I don't know enough about evaluating those prints to know what we got.

(Question inaudible)

Well, we discussed this during debriefing some, I think we must have had some ~~firing~~ spitting thrusters that weren't cutting off absolutely clean, that would add just a hair of thrust in one axis or another at a time because I would have the rates zero-ed completely and be sitting right on the spot ~~with~~

of magno control inputs and you'd start a little drift rate very slow. Probably the drift rates want out over a quarter of a degree per second during the time that I was trying to make the pictures. But thats enough if you drift off and you have to correct back the line you drift off a line correct back line, you do this for 15 or 20 seconds, its rather a crude way to take pictures.

(Question inaudible)

Yes. Hand held and had it up against the visor to steadiness and turn it very slowly. We had the loose site on the top of it. A loose site with a cross hair and so that I could keep that right on the--lined up on the stars. It will be interesting to see if we came out with anything on that.

Make any other comments about our _____?

No. It looks about like it does on the desert on a bright summer night.

Twilight. Did the twilight bother you at all? Can you tell us anything about that.

You mean the light I described after sunset?

(Statement by Dr. Roman, inaudible)

The only time twilight bothered either way was when you _____ because sunrise is the--the early pickup sunrise coming up is in the scope facing backwards, of course, to the direction of motion and you see the sun come up and this would--this twilight, you watch it incresing in the scope, meanwhile we're holding manual control most of the time and this was very difficult. For some reasons, this was more difficult to hold accurate control on the periscope at sunrise that it was to look back out the window and hold

it visually or on instrument. And since we were having automatic control trouble presentation on the attitude, I was trying to maintain control looking back out the window and to check back and forth between the very brilliant and bright light coming in at sunrise through the scope and look back out into the dark again, I finally just put filter over the scope and go back to looking out at the stars and what I could see on the clouds--moonlight coming off of them and that seemed to be easier to hold the position.

The moon look any different to you?

No. Not appreciably. It was brighter--a lot brighter. Just very clear. Once again, clearer than it is around here, brighter than it is around here. Once again, out on the desert on a real clear night, its very similar.

Lets push on to the earth questions on your next page, John. You said you had never used the interference filter.

No.

Okay, haze and airglow band at night?

Yes, I did try the airglow band at night and I could see nothing. This may have been the lack of night adaptation--I don't know. I wasn't too concerned about the night adapting so perfectly to that. I tried the airglow particularly on the storm areas over the Indian Ocean. There was a very large storm there to the North, of course, and a smaller one to the South of course, over about the first third of the Indian Ocean. We had wondered if we could see lightening from above and lightening from above is very, very visible. Theres no problem at all on that. You can see the flashes--you don't see individual flashes like you see a lightening bolt hit the ground here

but you see a whole thunderhead light up and _____

and another one would light up over here and there would be some light go back and forth from here like this very horizontally. And then you would see another one light up and there was a lot of thunderstorm activity particularly in the storm that was to the north, of course. A little less to the one south but the lightening was very visible.

Pretty much the same thing you see from a high flying jet, isn't it?

Yes. You're a little farther away, of course. Its similar to that If you've been up above the--40 or 50,000 feet at night and there is some little low thunderheads where you have the--maybe some of the flashing a little bit down at low altitudes, it would be a similar type thing. You're just farther away from it but there's to problem at all seeing flashes. It was on that area to the North, of course, in particular that I tried to use this airglow filter for a period of time but I didn't get any pattern out of it at all. This may have been my lack of night adaptation.

At twilight did you see the shadow of the earth on the atmosphere?

No.

Last of these. Can you describe how the atmosphere changed during the twilight process? You've already gone over this, if there's nothing you can add--

Well, I think that about describes it. One thing I was surprised at during the twilight period that might be of some interest were the little discontinuities in it but I think they were just weather build-ups and high clouds off on the horizon. I though the horizon would be extremely even and

that the weather would be so _____ that you wouldn't see any of this but you could see little bumps along in the twilight glow after the sunset and this shows up in some of our pictures. F You can see these little bumps along. Do you have copies of those up here?

Not up here. I saw some that were first run yesterday down at the Cape.

We had a first look at these out at Grand Turk. I think the copies we got were not the best in the West. They seem to be a little rough. They had a lot of specs on them and I'm looking forward to getting back down there and going over them again. But you could see some of these. You could see a little bump out here, there would be a little discontinuity.

..... angle or altitude.....(question, partially inaudible)...?

No. They were in the lower part of the light band so I assume that they were weather build-ups.

What did you estimate the height of the atmosphere to be under daytime conditions? In fact, this angle of the horizon business?

Well, estimates on the angle, saying that this was some 6 to 8 degrees wide, up to this layer for instance was about 6 to 8 degrees wide and it was maybe a degree and a half or two degrees think. This sort of an estimate of the size of the _____ over here. We're about 30 degrees in the window our angle we can look out and a little less than a quarter, maybe a fifth of this business of--say if you estimate about 6 degrees. When I say 6 to 8 degrees this is not an accurate protractor type measurement.

Could you use a spacecraft as a protractor?

Well I used the window, just the window area

..(Question,.partially.inaudible).... from the top of the window from the horizon up to the top of the atmosphere? ..... read it off from the autopilot?

You might be able to try this. I didn't try it that way. You might be able to, holding your head fix you might be able to do something like that. This would be fairly accurate. This would put it down, I think, where you could pick it off within a--our gradations on that attitude control system are fairly fine--about, I guess, three sixteenths of an inch is 10 degrees but you y could pick it off to within a degree and a half or 2 degrees with pretty fair accuracy.

I notice in some of the pictures there is a second order image of the sun about 10 degrees from the primary image apparently due to the 2 thicknesses of glass.

Yes. I think thats what it was from. I don't recall seeing any of those at all. I notice them in the same pictures and there was another phenomena in the pictures you may have noticed. In quite a number of them--I think Bob noticed it first before I had--up above the horizon some 15 or 20 degrees there appeared to be a green band go across that parallel the earth's surface. Did you notice that in thepictures? And this was in quite a number of them. And I never saw any band like that at all. I don't know whether it was actually there and just showed up on the film and I just didn't see it or couldn't see it or whether it was always when the sun was at a particular area out here and it was just a certain reflection off the window or reflection off the lens of the camera but I think we should probably take those pictures and try to analyse what angle the sun was to them as well as we possible can.

I think John is doing that right now.

Is he? Because this green band is a new one on me. I never saw that until we got the pictures and I imagine its just a reflection on the lens.

through the window like 2 suns or satellite.....?
Did.you.see.any multiple images./...(question partially inaudible.....XX

No, no.

Could I _____ a question here on the surface?

Go ahead.

I notice on the picture here and also the comet the description of the _____on the horizon in the daytime. _____ _____ around thehorizon near the sun.. Was this a uniform thing _____ _____.

No. It comes out even in broad daylight. It seems to go out to a little more of a pointed area out--way out the horizon if you leaned over and look out the ~~window~~window way out toward the North, for instance. This would not be as broad a band as it appeared to be when we're ~~x~~ looking back directly on the flight path, for instance.

It does appear to exist 350 degrees?

Oh yes.

Were there any appreciable irregularities in it or was it completely smooth?

Smooth. These are very--there are fuzzy edges. You don't run up like you see on the spectrum to this color and to that color. They all fade into each other like a rainbow but its a--there are no ~~minimum~~ discontinuities where a yellow band was more thick than a blue band here or something like that. They all just ran out even.

Are you referring now to the sunset phenomena?

That true then too. I was speaking primarily just during broad daylight.

Do you get different colors in broad daylight other than the blues?

Just the Blues and whites during broad daylight. Yes.

You notice any--very many clouds or any peculiar cloud formations?

Yes. We got quite a number of cloud pink pictures and you can pick out the relative types of clouds. We did wonder whether you could tell vertical clouds from SER-OS clouds. You can tell what clouds are vertical development and you get a three dimensional effect. Looking at them you can tell that some are higher than others.

Comparing what you said with what the picture showed, is there anything particular noteworthy that you might have seen that the pictures might not show?

I don't think so other than the things we have mentioned here.

(Question, inaudible)

Is what Now?

Does your window produce any polorization?

We have a real limited degree of polorization in the window.

How many_____ do you have in _____ form?

I will make a note on that one and check the exact polorization of it. We had--this was checked at the time that we ran some star studies in St. Louis when I took the capsule out_____.

The reason I asked _____

_____.

The exact figure on that I can't give you.

Did you pass over any snow propagations, mountains _____?

No. I could see out in the West looking way up North from the area right over--well the South of San Diego at the end of the second orbit. There was so much cloud cover up to the North that I couldn't be real positive.

It ran up and looked like it ran off the edge of a _____. Then there were some white areas way up to the North and I imagine these were probably snow fields. I thought at the time they probably were but I couldn't be sure. I didn't specifically go over any area where I could look right down at this cloud and that snow. I was surpsised at my--and another thing, as far as the weather goes, and that is what a tremendous area of the earth was is covered by clouds that day. I don't know whether we're going to find that this is customary or not. But I was surprised. I had very little view of land. The equatorial regions

M .....(Statement, inaudible).....

Yes. The intertropical _____. We had been briefed on that and, of course, that took care of things all the way across the Pacific. There was cloud cover all the way across there. There was cloud cover over all Eastern Africa. I never saw the Lake Chad area that I was looking for. It was covered. The only part of Africa we really got a good look at was Western Africa in the desert regions. You could see the big x dust xxx storms blowing and these were very visible. I commented on it and Kenya came back and said yes that they had been having these dust storms for about a week. Tremendous blowing clouds of dust that obscured large--very large areas of the ground. Coming across the states end, this whole area across WI-NAS and Northern Mexico, Southern California and that area had very large cloud decks and high SER-OS clouds obscured vision from above. There were some breaks in it and you could see through momentarily.

What color were the dust clouds?

They just looked like dust. Brownish. Just looked like a dust storm you've seen out on the x desert. Same color. The colors from above looked--

I could see no difference in flying in an airplane at 50,000 feet and looking down and seeing colors on the ground than there is from the capsule.

Lets
~~Let's~~switch the subject again. Did you have an opportunity to try closing your eyes and seeing the Sorenkoff Radiation flashes?

Seeing what?

Radiation flashes from energetic particles fastened to your eyeballs.

Is that another _____. First time I heard of it.

What do you call this again now?

Sorenkoff Radiation by a good Russian friend of that name.

Golly, they missed that one on briefing.

(statement, inaudible)

When a cosmic ray passes through a material in which the--its velocity exceeds the velocity of light in the medium you have this radiation given out-Sorenkoff Radiation and John Winckler of Minnesota thought that you might be able to observe this if you shut your eyes when the heavies came through.

(statement, inaudible).....

Are these suppose to be very visible, very bright or just--

No one knows because they never get down to the earth's surface. They would have been in the blue light.

We didn't ride around for any period of time with the eyes closed. There was enough going on that--this eye patch, we had that. That was intentionally done, not to two eyes, just to one so that you'd still monitor everything that was going on. So I did not ride around with the eyes shut any period of time.

Alright. Lets get to the luminous particles. Back to page 1.

Thats a good one. That sure is.

Were they all traveling in the same direction and the same velocity?

Yes. They all just appeared to be ~~xx~~ sitting out here floating and they particular didn't have any interaction with each other. They were-- some went running this way and some that way. They all appeared just to be static in their field. I was moving through them. The only ones that appeared to move were the ones that seemed to have a little flow characteristic around the capsule, and this was surprising too because there would be one that would come following up around the edge of the capsule and it would drift off like this and it would just more or less take its place back here. If this had been ~~xx~~ just a flash, just a momentarily thing, I don't know, it would have been--I don't know what I would have thought on one like that. I sat there and observed this thing just as carefully as I could observe it for some 3 to 5 minutes at three different periods. The lights were not very dim little lights as though reflections from something. They were every bit as brilliant or more so than fireflies out on a real black summer night. And you've seen fireflies out in the meadow or when they just stand out like very, very bright stars. They were as least as bright as the brightest fireflies you've ever seen in a situation like that and the light was very steady and they were about the same color as fireflies. This was a luminous yellow-green or green-yellow color. I'd say it was almost an identical to a firefly and they were just as far at that particular ~~xxxx~~ time. I would look out the window this ~~x~~ way and there just seemed to be no end to them out here, no end back this way, no end on this side, up or down in particular .

(Question, inaudible).....

Yes.

The density looking perpendicular to your path is about equal to that _____.

I had 2 things came in mind. One was, I thought we founda the lost Air Force needles, that was the first thing. But they weren't--wasn't like that at all. The other thing, I thought perhaps we were getting freezing of the water coming out of the capsule and we were having snow, something like that. In fact, later on they called me from the ground and asked if I thought that that is what it was. But it wasn't that type thing at all. It didn't appear to be eminating from the capsule. The particles were not closer together--closer to the capsule than they appeared to be further away. The average distance of the particles apart was probably--I estimated I think some 6 to 10 feet, in that neighborhood. Occasionally one would be right in the shadow of the capsule and would drift up pass the window and it looked rather white like a wee tiny little piece of cotton or a little--it looked like a little snow flake. Some little piece of thing like that. These white ones that I saw come up by like that I assume were the same things as the others out here because I never saw anything else outside of the window.

Did you ever see the same one go into the shadow and come back out?

Well, I was asked that before and I--my initial answer to it was yes and then I couldn't recall any real specific instance where I watched one go from luminousity to white and back to luminous again. So I can't say positively I did on that. I think they did but I don't want to make a positive statement.

(Question, partially inaudible)..... in the shadow of the capsule they were simply white like snow?

Thats right, thats right. They were very liminous. When the first rays of the sun would come--when the first rays of the sun came by the capsule is when I'd see the first ones and this persisted then some--oh, 5 minutes.

(Lengthy question, inaudible).....?

It could be. I won't say it was. I won't say it wasn't.

I don't know how you could have much depth perception but do you have any idea about how far away the fartherest ones were?

No. I couldn't estimate how far away they were but you had a very definite feeling of depth perception through them, mainly, I think by looking out to the side out here. And if you had a lot or particles hanging out here and you move through them see the ones move as you move them them and the near ones move right within. Ones far out move very slowly so this gives you a sense of depth. And I think that the way I perceived most of that.

You say they're all moving in the same direction?

Thats right.

Did any move faster than others?

They didn't appear to. They all appear to be hanging except for the ones that seemed to come up around the capsule in this flow condition.

(Question, partially inaudible) Did that flow look anything like _____?

Yes. Thats what we talked about. It did. The few particles that came by was just like a _____ almost.

(Statement, partially inaudible) _____ _____ advancing a new theory that this might very well be some full luminescence of areas _____ around the capsule _____ we talked about this night and day change_____. Whether theres anything of this kind _____ recombination back in the shadow of the capsule_____. Five miles an hour _____motions _____ area of capsule speed and so on. It certainly seem--it seem to be connection with the capsule in some way and not with something coming from outer space.

I estimated 3 to 5 miles an hour differential speed and I--it wasn't over five miles an hour., thats definitely on the high side if we get up to that. They were just very slowly drifting by. They gradually start disappearing as the sun came up and we got up at more of an angle they gradually start disappearing. And I couldn't see anything.

Did you see them before the sun rose?

No.

Did you look for them before that?

Yes. The second time around I was watching for these things.

But you did see them as soon as the sun rose?

The very first light of the sun--the very first rays of the sun than came up, you could see the first ones appear just like that when the sun came up.

(Question, inaudible.....?

Yes.

Do you have an impression of the shape, the structure of the individual particles.

No. These one that would come fairly clost to the capsule I could see. Thats where I estimated they were just a very tiny size up to maybe 3/8 of an inch or half an inch.

Would you characterize them as sort of irregular like cornflakes, like crystal, like snowflakes?

They didn't appear to have any oblong pattern to them or any particular circular pattern. No real semetry at all.

Were they flat like snow flakes?

These little white things which I x think were the same items were right up close to the window in the shade looked a lot like little snow flakes.

Would you say they were speherical or _____?

I think more like sort of a _____ sphere.

_____ any distance at all and ~~xxxxxx~~ they were luminous and the sun was on them and there was no ~~xxxxxx~~ shape to--just like looking at a firefly light. That's the nearest thing I can come--I keep coming back to because that's just what they looked like.

(Question, Inaudible).....?

No. No. There was no on and off again type thing at all. This was another thing that going back to the stars it was noticable too as we had expected there wans't any of the--I didn't notice any particular amount of twinkling of the stars, not like they do down here.

Did
~~XXX~~ you see any of these particles move _____?

No. Its just like you have a big static field like you have gone out here with strings and placed them in this room and if you cane back and through that door and back to way across the room that just what they looked like going by. It just wasn't--

They all went by in the direction of_____?

That's right. Now, I turned around once so I could see if they were coming toward me. I got around facing toward the sunlight. As I came around and the sunlight was off to my right I could see far fewer of them at that time than I could see when I was facing backwards. This would be on the side away from the sun is where I could see most of them. But they--the ones out here were still coming towards me. Now this is--I want to check and see if these were eminating from the capsule. They were not. They were still coming toward me from out there so they couldn't have been eminating from the capsule.

From the direction toward which you were moving.

That's right.

How close_____?

Six to ten feet apart.

(Question, partiallyinaudible) .....you said you saw it 3 times. Did you? This was approximately the same.....?

Well, this was right at each sunrise. Now this wasanother thing we talked about. Bill Douglass, I think, felt that there might be some possibility if the earth does have its own band around the equator, just as some of the planets do, that perhaps were were at the edge of a little band like that that was appearing each time we came up past the equator on the dark side and it just happened to coincide with the sunrise at that time. We entered at sunrise each time. We don't have the data--I haven't checked back here to get the data on that yet as to whether this was always right at the equatorial region that we ran into.

(Question, inaudible)....?

Right at the first light of sunrise there was a--no other time. I specifically looked for them at sunset. As the last light of the sun went away I thought we might see them there. I didn't. This was always at sunrise. Now, this difference may be that I was more night adapted _____ at sunrise. Maybe they were there all the way around.

(Question, inaudible).....?

We're running short of time here. Let me get through a couple of these right quickly.

Whats the longest time you require watching any individual particle?

Oh, I can't answer that as to the length of time I specifially watched one particular particle but they were not blinking on and off or anything like that.

Did you have the impression they would be there if you _____?

_____they were about 6 to 7 feet apart. The window is only a certain size - _____.

(Statement, inaudible)

Well, I had the impression I could have sat--I could have been sitting there and watch one particle for some distance as it went on back maybe for a minute or so.

When they were in the shadows of the spacecraft, did they appear to vary any in brightness ?

No. They weren't luminous when they were in the shadows. I can't specifically say. I watched 8 particles from a luminous condition to in the shadows non-luminous and back to xx a luminous condition.

(XX Question, inaudible)...?

Oh, yes. I think this is very probable. I could have seen it farther than that. They were bright. If you were night adapted and you can see a very bright firefly from a considerable distance and this was a--

When you saw this the second and third time around did you have the feeling that there were any more of less than there was the first time?

No. We talked about that too and I think it was the same type. I don't think the density of it was any different. Completely snowed. The first time I saw these I looked down into the--I checked some systems--had been looking outside the _____ the cockpit and made a check a _____ check as I was doing all the time and had had my head in the cockpit for some little period of time and glanced back up at the window. I had been doing this just

as I could start to begin to see some faint light down below and I glanced back up at the window and my first impression was, ~~mmmt~~ well we've gotten way out of attitude and probably come to the _____ because here it was just like looking out on a complete star field, there was no other reference at all and looking backward toward this dark area what had happened, instead of the even horizon back here that I had had with the stars up above and the darker area down below. Now in this dark area down below too were all these other lights pinpointed in. They just looked, at first glance, like a continuation of the whole star field down into that area. I thought we had drifted up and here I am looking at nothing but a starfield and how did I ever get into this crazy attitude. I checked instruments again and checked the periscope again and I hadn't drifted. I was still in the same attitude I was in except this.big darker area here that had been the earth back behind it that I had been looking at was now filled up with all these dots as the first light of the sun surfaced.

How long after the sunrise did you observe some of these in the shadow of the spacecraft? Was it almost immediately or towards the end of ~~thm~~ this _____ period?

Oh, I don't think there any difference on that as far as when they would drift up into that. This could well have been occurring just as well when I first came into them as they could at the end of the time. I didn't have any impression that there was more ~~drift~~ drift by the capsule at one time than another or more flow around the capsule that pulled them in past the window at one time or another.

You can't see them on the film?

No. The ones we had out there at Grand Turk I couldn't very--we had to many scratches and spots on those pictures that I couldn't really pinpoint them. But when we get hold of the original pictures and can project those, I hope that we can see more, I don't know. Those reproductions we had out there were not very satisfactory. I hope the originals are better than that. Did you see the originals? Are they clear?

I saw prints which I think _____ started to develop. They seem fairly clear.

Did you see any of these spots on them? Did you have the film? Did you look at the film?

I did not look at the film directly. But it not the sort of picture _____ you had in Grand Turk. You had a really good clear print that day.

Thats right. And the way they looked they were pretty _____. They weren't the best job I ever saw. I'm afraid I don't know waht to tell you except that. I wish I could be more helpful. All I can say is we observed it and it was very clear and distinct. It wasn't a reflection from anything. It was very positive. We observed it a long period of time on three different orbits at exactly the same spot. Beyond that, I have not the foggiest idea what it is.

We they all the same color?

Yes. E Very even colored except that some of them would look a little larger than others, a little brighter than others. The color was identical.

Were there any changes in brightness/looking out the side cross your _____ and back?

No. I don't recall any. We talked about that too and I couldn't recall that they looked any different in one direction than they did in another.

(Question, inaudible)....?

No.

(Statement, inaudible)...

It might well have something to do with differences in electrostatic potential._____.

(Question, inaudible)...?

The drift would be like--well if you were looking out--well if a snow flake come drifting by the window is something goes ~~2~~ very rapidly, of course. As I was looking out the window, there maybe be/little particles just come _____just come up across the window and maybe _____ around and then drift away and as it got out there a ~~litt~~ little bit it just seemed to assume its position out here.

(Statement, inaudible)...

Oh, no. It was not a thing where the thing just came around on a/very smooth trajectory and run off like this. It would drift up around here like that and then it would drift off on it own. It looked very much--it just looked like snow. It looked like blow like you ~~yo~~ would see in a ~~wind~~ wind tunnel only with a single particle.

Do you have any _____ on your capsule?

I'm sure there is. I don't know what it is but I'm sure there must be some.

There would not only be an electric charge, there would be a differential charge between the window and the outside of the capsule which could explain_____.

(Statement, inaudible).....

(Question, inaudible)....?

Well, thats a pretty tk tough one. I don't know. That would be like-- I hate to be too positive because it might lead you astray but I keep coming back to the fireflies again. Very, very similar to looking out at this-- a big firefly or little firefly. Looking out on a real dark night in a pasture this might be a small firefly up close and a big firefly farther away. As you drift through these things they go by, they all look reasonably uniform. The ones that are up close and some of the luminous ones were up very close.

Definitely, did that make sense?

As they would be up close and then drift away they didn't appear to diminish their light very rapidly. Just like seeing a firefly again.

Well John you kept your date with us promptly. I think we should let you go promptly.

I hate to break this up too because I want to find out what these things are. I don't know what to tell you. I'm afraid I'm about dry on new information.

I won't ask you what did they say John _____.

I may have to go back and check them. I'm ready.

(Statement, inaudible)....

I'd like to get together again because this was the first real honest to goodness business like this we've conducted since I got back here and this is what I want to get back to next week. I'm going back to the Cape Monday night. I'm going to be down there all next week on touring plan and then probably back down ~~xx~~ the following week again until we get a lot of this. I want to go through the ~~finxx~~ films and _____ and get back to work and finish _____ this type thing this week.

(Statement, inaudible)...

I don't think there's any great urgency from our point of view mainly it was to get the first impression there is always debriefing.

Any time you would like to get even with us _____.

(Conversation, several people, inaudible)

Thank you Glenn.

Thank you.

Date Mar 13

ROUGH DRAFT: 3/13/62
CODE SCG: MD:dd

MEMORANDUM to Director, Office of Space Sciences

Subject: Considerations and Recommendations of Manned Space Exploration Following the Interview (February 27, 1962) with Lt. Col. John H. Glenn, Jr. Col. Glenn presented a ~~very~~ detailed and factual description of his observations during the MA-6 flight. He answered rather well the many and varied questions presented to him during the limited interview. Despite the fact that he was ~~seldom, if ever,~~ never properly dark adapted, a number of his observations remain of ~~great~~ interest for possible further exploration. Furthermore, it is evident that the astronaut can perform various scientific experiments, and he has the ~~ability~~ capability of doing so despite the many limitations imposed by the compact Mercury capsule. Some comments on Col. Glenn's observations are presented below followed by a number of recommendations.

Luminous particles: In response to a series of questions, Col. Glenn described the velocity field of the luminous particles, their brightness in and outside the shadow of the spacecraft, the coloring in sunlight and their shape. For the velocity field, the particles all moved at precisely the same speed and all moved in precisely the same direction except for particles coming very close to the spacecraft. This occurred in a fashion for all three orbits. From ~~the velocity~~ dynamic considerations alone, it may be stated that the luminous particles observed by Col. Glenn were not extraterrestial particles but were particles associated with the spacecraft or ~~the launching or~~ the booster.

The consistency in the observations on the three separate orbits would require that the particles were associated with the spacecraft itself (I have heard that O'Keefe has ~~investigated~~ suggested that the life support system which ~~would~~ dumped water may have been the source of the particles) ~~water into space~~) Col. Glenn ~~XXX~~ described the particles ~~and the~~ shape luminosity. The fact that the coloring was a yellow-green and the ~~effective~~ apparent observational ~~picture described by Glenn~~ description would indicate that the particles became fluorescent in sunlight. The particles observed in shadow were observed in the scattered light from the spacecraft and were probably illuminated only by visible ~~part~~ portion of the spectrum.

-2-

The change of angles of the particles approaching close ~~th~~ the ~~XXX~~ spacecraft ~~could~~ can be attributed to the repulsive charge ~~XXXX~~ since the polarities of the particles and spacecraft were the same. The ability of Col. Glenn to observe the particles under improper dark adaptation ~~would~~ could indicate that an astronaut would be in a position to carry through a series of experiments to investigate the physics of ~~comments~~ comets in the solar environment. ~~Properly dark adapted~~ the various gases and dust particles ejected from the spacecraft during twilight conditions and ~~during~~ while the spacecraft is in sunlight could be ~~examined~~ observed with instruments and by the astronaut-scientist, ~~and the results could be recorded with instruments.~~ if he is properly dark adapted.

Observations of air glow and haze: Limited by poor dark adaptation, Col. Glenn was not able to descibe any

significant observations of the starfield or the moon. In the absence of atmospheric scattering the sun appeared a brillant white, but showed no signs of corona. It is of interest, however, to consider Col. Glenn's observation of the twilight indicating a band six to eight degrees above the horizon, with a haze layer about two degrees wide at the top. Although it has been speculated that the multiple layers of the observation window could cause the high angle to the horizon of haze with the air glow and haze layer, this may be unlikely because of the variations and angle of view allow to Col. Glenn of rotating the space craft, Col Glenn said and the fact that he did not see any double imaging in observing during any of his other observations, Furthermore, he was able to indicate state that the stars observed through the haze layer became less intense while changing angle near to below the horizon. The USSR reports by Titov also indicated a high angle haze layer of the. It is evident that The airglow was observed with the 5577 filter, was not observed without it. 5577 further investigations of the air glow and haze layer should be carried out.

The airglow should be detectable by visual observations after dark adaptation.

Meteorology: The striking condition intensities of lightning discharges as observed by Glenn point the way to consideration of an ejection detection system for monitoring lightning storms over the earth using the meteorological satellite. The mapping of the distribution of thunderheads with lightning during the night appears to be relatively straightforward, while the similar mapping during daylight appears feasible because of the short time constant of the lightning flashes.

Recommendations: There are A variety of number of

have become evident

recommendations ~~appear to be aparent~~ following the very successful flight of the Mercury capsule.

1. The astronaut-scientist ~~carrying out the observations from a space vehicle~~ describe his observations by an paper should, if desireable, publish under his name (with an associate) ~~an general article~~ in a widely distributed scientific journal following a successful flight. In this manner, these first-hand observations would have wide distribution, be properly credited to the observer, and would be edited for correctness.

2. Additional support to the astronaut in carrying out scientific observations is warranted particularly in consideration of Col. Glenn's attitude and interest in carrying out such observations. Several instruments may be added to the spacecraft, within engineering limitations, to assist in obtaining further detailed data.

3. Col. Glenn suggested that a follow-on discussions would be to his interest. Such follow-on discussion is strongly recommended for further questions and exchanges, and to inform the astronaut analysis of the results of the ~~evaluate for the astronaut~~ and study of his observations.

4. It is very important that proper dark adaptation methods be incorporated into the spacecraft system so that the astronaut may optimize his visual observations.

5. Investigations of the physics of comets and the feasibility of the ~~capital~~ "Artificial Comet" experiment may be carried out directly by the astronaut in a relatively straightforward way. These experiments should be carried out to assist in evaluating the feasibility of this experiments.

6. For air glow ~~and optical studies~~, ~~the~~ a photo-multiplier ~~for t~~ system ~~and a~~ series of filters (including ~~a possible fluorescent plain filter to study the ultra-violet~~ by flourescence) should be incorporated into the spacecraft.

~~Because a number of scientific experiments appear reasonable following the success of the Mercury orbital flight, and~~ In consideration of the present ~~re~~planned manned-space-flight-program, ~~some recommendations are apparent to~~ we should take advantage of ~~the improvements in the~~ this activity to improve the space science program. ~~scientific exploration of the solar system and~~ In astronomy. At headquarters ~~it is recommended that~~ consideration may be given to: ~~the following~~:

a. The assignment of a ~~A~~ Program Chief and supporting staff ~~in the space science~~ reporting to the Director of Space Sciences for scientific exploration ~~of~~ in the Manned Space Flight Program ~~and~~,

b. The formation ~~b. of~~ that a committee or sub-committee ~~be formed~~ including such people as ~~Roche~~ each, ~~Mitra~~, Minnaert, Tousey, Sekera, ~~and so forth~~ etc. to ~~include~~ bring in the scientific community ~~and the in this activity~~ and,

c. The formation ~~of~~ that a branch or division at one of the centers ~~be created~~ as a scientific team ~~for direct~~ carrying out scientific experiments support of the astronaut-scientists ~~who venture into sys-solar? space~~ in carrying out scientific experiments.

M. Dubin

Head Astronomy Program

cc: Mr. Fellows cc: Clark

Mr. Dubin

In reply refer to: SGA(JRG:aml)

FEB 23 1962

MEMORANDUM for the Files

Subject: Telephone conversation with Dr. John O'Keefe from Cape Canaveral

The following information was gathered from a conversation with Dr. O'Keefe on Wednesday, Feb. 21, 1962:

Astronaut Glenn reported having seen small luminous particles during his flight. They appeared to be moving at a speed of about three or four miles per hour. They were apparently not more than 100 feet away from the capsule, and were visible by binocular vision. Their color was golden like fireflies, and they seemed to be more to the rear of the capsule than ahead of it, though they were visible for great distances all around. These particles were visible only at sunrise (not at sunset), and the capsule seemed to be immersed in them. They very definitely had nothing to do with the capsule or its movement.

Glenn also reported that very clear pictures of the stars, including Orion, had been taken with the UV camera, although the capsule motion had caused a "wiggly" view.

Jocelyn R. Gill
Staff Scientist
Astronomy & Solar Physics

U.V camera - 2900 - 3000° A° - thru Vycor window of Mercury capsule

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IN REPLY
REFER TO: J-16-812

July 13, 1962

Dr. Jocelyn Gill
Room 62033
Federal Office Bldg. No. 6
Headquarters, N.A.S.A.
Washington 25, D. C.

Dear Dr. Gill:

The June 29 issue of Science brought to my attention J. H. Glenn's comments on "The High Layer". It seemed possible that the layer he described could be accounted for as a region of relatively large nitrogen peroxide (NO_2) concentration, and the past two weeks have been spent in checking this hypothesis. Unfortunately I am not familiar with either photochemistry or upper atmosphere physics so the following analysis leaves much to be desired; the hypothesis seems tenable, however, so I would like to bring it to your attention.

Effective path length and comparison with possible surface observations.

Referring to Figure 1, the height (H) of a point at a distance (L) from a point on the surface of a sphere of radius (R) can be found from the formula

$$(R+H)^2 = R^2+L^2+2RL \sin \Theta \qquad (1)$$

which has the solution

$$H = R\left[-1 + \sqrt{1 + \left(\frac{L}{R}\right)^2 + 2\frac{L}{R}\sin\Theta}\right] \qquad (2)$$

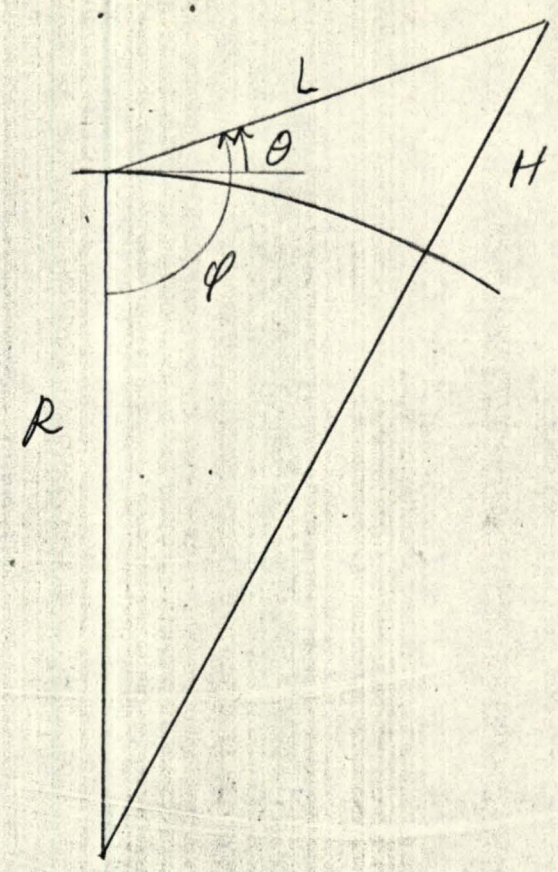

Figure 1

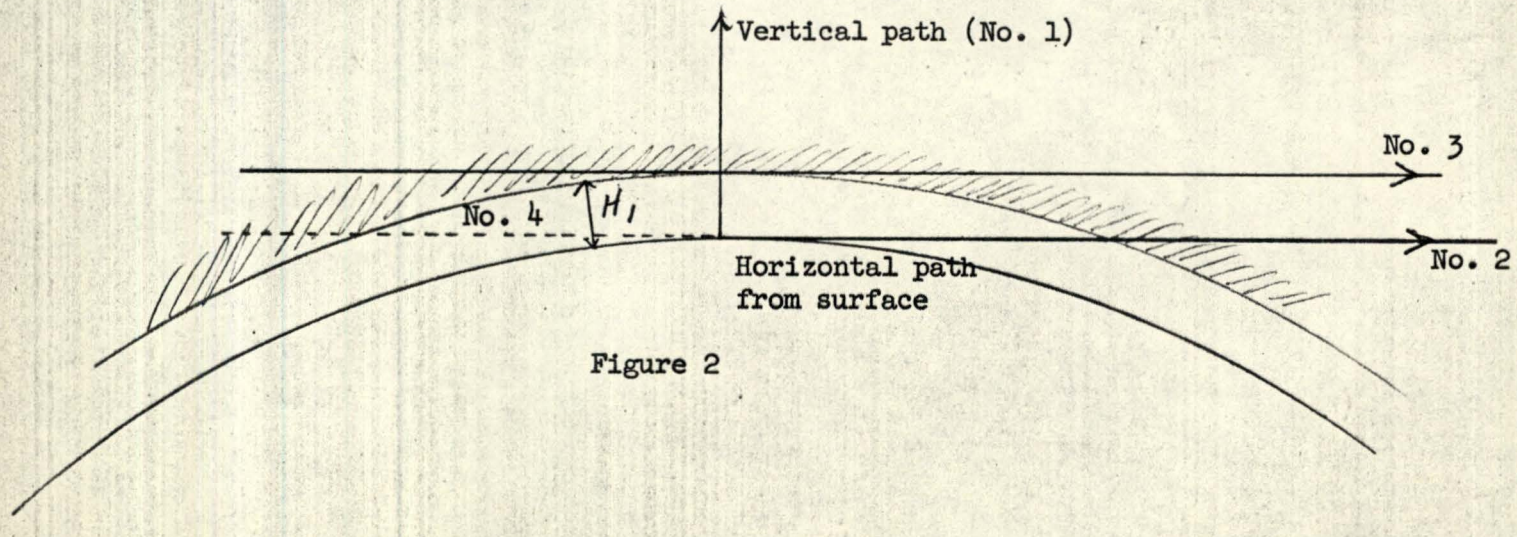

Figure 2

For the following I will assume that the concentration of absorbing molecules in the region of interest can be described adequately by an exponential decrease with altitude above the bottom of the layer, hence, can be represented by

$$\rho = \rho_o \, e^{-\frac{H}{Y}} \tag{3}$$

where Y is the scale height in the layer and H must lie in the layer. Then the number of molecules per cm^2 is found to be

$$N\left(\frac{\text{molecules}}{cm^2}\right) = \int \rho(H)\,dl \tag{4a}$$

$$N = \rho_o \int e^{-\frac{R}{Y}\left[-1 + \sqrt{1 + (\frac{L}{R})^2 + 2\frac{L}{R}\sin\Theta}\right]} \tag{4b}$$

$$= R\rho_o \int e^{-\frac{R}{Y}\left[-1 + \sqrt{1 + y^2 + 2y\sin\Theta}\right]} dy \tag{4c}$$

$$\left(Y \equiv \frac{L}{R}\right) \tag{5}$$

where the integral is over the range of y desired (usually $0 \rightarrow \infty$).

For a vertical view ($\sin\Theta = 1$) path, the solution is simply

$$N_1 = Y\rho_o \tag{6}$$

where ρ_o is the density at the base of the layer.

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For a horizontal path ($\sin \Theta = 0$) tangent to the base of a layer (path No. 3) we note that $y \ll 1$ in the contributing region, hence, can get an approximate form

$$N \tilde{=} R\rho_o \int_o^\infty e^{\frac{R}{Y}\frac{y^2}{2}}\, dy \tag{7}$$

which has the value

$$N = \sqrt{\frac{\pi RY}{2}}\, \rho_o \tag{8}$$

Here ρ_o is the density at the base of the layer, as in equation (6).

An astronaut's view thru a layer from above would see twice the path computed by equation (7), giving

$$N_3 = \rho_o \sqrt{2\pi RY} \text{ molecules/cm}^2 \tag{9}$$

A line of sight tangent to the earth and passing thru a layer at base altitude H (path No. 2) will have

$$N = \frac{RY}{L}\left[\rho_1 e^{\frac{H_1}{Y}}\right] \tag{10}$$

and we note that $\left[\rho_1 e^{\frac{H_1}{Y}}\right]$ is the density at H_1, the base of the layer, which we set equal to ρ_o as in equations (6) and (9),

$$N_2 = \rho_o \frac{RY}{L} = \rho_o \sqrt{\frac{R}{2H_1}} \tag{11}$$

Assuming that Y = 7 km in an absorbing layer, we note that a surface observer viewing a layer at an altitude near 100 km will have available the ratio

$$\frac{N_2}{N_1} = 5.5 \tag{12}$$

An astronaut viewing along path No. 3 would have a much greater thickness, as

$$\frac{N_3}{N_1} = \frac{2\pi R}{Y} \simeq 75 \tag{13}$$

Viewing thru the layer to a point near the surface and out again the enhancement would be much less,

$$\frac{N_4}{N_1} = 2\frac{N_2}{N_1} = 11 \tag{14}$$

Light received by an observer from a "point source" in space is attenuated by a factor $e^{-\sigma N}$ where σ is the absorption plus scattering cross section, giving

$$\frac{I}{I_o} = e^{-\sigma N} \tag{15a}$$

and

$$\ln \frac{I}{I_o} = -\sigma N \tag{15b}$$

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From the report in Science, I infer that for the layer reported,

$$1 < \sigma N_3 < 5 \tag{16}$$

or

$$\sigma N_3 = 3 \pm 2 \tag{17}$$

giving

$$\sigma N_1 = 0.04 \pm 0.027 \tag{18}$$

and

$$\sigma N_2 = 0.22 \pm 0.15 \tag{19}$$

Any such absorbing layer present during the day would result in rapid heating, and reradiation in the infra-red range from whatever bands may be present. However, the absorbers postulated below would be destroyed by photodissociation and/or heating during the day. Hence, it is not surprising that solar spectra have not shown such an absorbing layer.

Stellar, planetary or lunar spectra might show the existence of such a layer, if the absorption spectrum has sufficient structure.

Setting $X_i \rho_o = N_i$ (20a)

we find the effective path length X_i.

$$X_1 = 7 \times 10^5 \text{ cm} \tag{20b}$$

$$X_2 = 3.9 \times 10^6 \text{cm (starting absorption at 100 km altitude)} \tag{20c}$$

$$X_3 = 5.4 \times 10^7 \text{cm} \qquad (20d)$$

$$X_4 = 7.8 \times 10^6 \text{ cm} \qquad (20e)$$

Absorbers Present in the Upper Atmosphere

Three constituents of the atmosphere near 100 km altitude absorb light through most or all of the visible range, as would be required to get a noticeable dimming of starlight.

They are: 1) NO_2 (nitrogen peroxide)

2) O^- (negative atomic oxygen ion)

3) O_2^- (negative molecular oxygen ion)

Of these, I found no cross section data for O_2^-. For O^-, Massey (Negative Ions; Cambridge U. Press) gives curves showing absorption cross sections starting at 5620 Å and approaching $\sim 4 \times 10^{-18}$ cm^2/ion in the region $\lambda < 5000$ Å. There is very little structure (only the onset at 5620 Å).

From equation (17) we find that

$$N_3(O^-) \cong \frac{3 \pm 2}{4 \times 10^{-18}} = (7.5 \pm 5) \times 10^{17}$$

could explain the observed attenuation.

For an effective path length of 5.4×10^7 cm, we have $\rho_o = (1.4 \pm 1) \times 10^{10}$ negative ions/cm^3.

Since the daytime free electron concentration in the E layer is 1.5×10^5 and the night value is $\sim 10^4$ it seems hard to believe such a high nighttime concentration of negative atomic ions.

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Nitrogen peroxide has been extensively studied and two papers were found which gave absorption coefficients in the visible region of the spectrum. Wiley and Foord (Proceedings of the Royal Society A135, 174 (1932) give a coefficient which I convert to

$$\sigma \sim 1 - 3 \times 10^{-19} \text{ cm}^2/\text{molecule}$$

depending on the wavelengths selected by their filters (the lower value was for the range $4900 < \lambda < 5250$ Å).

Hall and Blacet (J. Chem. Phys. 20, 1745 (1952) give a curve obtained with a Cary spectrophotometer having ~ 5 Å resolution. Maximum absorption occurs in the range $3500 < \lambda < 4500$ Å and drops to ~ 1/2 the peak value at 5000 Å. They give no data for longer wavelengths. I convert their absorption coefficients to $\sim 6 \times 10^{-19}$ cm^2/molecule at 4000 Å, and $\sim 3 \times 10^{-19}$ cm^2/molecule at 5000 Å. Structure produces changes in cross section of $\sim 2 \times 10^{-19}$ cm^2/molecule at wavelengths separated by a few angstroms.

Taking an average value of 4×10^{-19} cm^2/molecule, we find

$$N_3(NO_2) = \frac{3 \pm 2}{4 \times 10^{-19}} = (7.5 \pm 5) \times 10^{18} \text{ molecules/cm}^2$$

and using $X_3 = 5.4 \times 10^7$ cm

$$\rho_0 = (1.4 \pm 1) \times 10^{11} \text{ molecules/cm}^3$$

Readily detectable structure would produce variations of σN_1 and σN_2 of about half the attenuation figure given in equations (18) and (19) which is near the threshold of detectability.

I have not yet found an author who estimates the concentration of NO or NO_2 in the atmosphere; Bates and Nicolet discuss the reactions which lead to it in the book "The Earth as a Planet", edited by G. P. Kuiper (Volume II of The Solar System).

Nicolet calculates the photodissociation time as 200 seconds during daytime, and shows the concentration must be so low that no effect on solar observations would be found.

As a general conclusion, it seems to me more likely that NO_2 would be responsible for an absorbing layer, generated perhaps with the aid of downward diffusion of NO to higher pressure regions favoring oxidation to NO_2. The color suggested by Glenn fits very well, as may be quickly verified by looking thru the vapor space above concentrated nitric acid.

Experimental Proposal.

Ideally, one could ask for the absorption coefficient as a function of wavelength (over a very wide spectral range) and time after sunset on the air volume investigated.

It seems possible to get very useful data with a relatively simple experiment perhaps possible of inclusion in one of the manned orbital flights.

Using a slow-speed movie camera, photograph the star field and such planets (including the moon) as opportunity permits, with approximately a 10° field of view and enough exposure to permit photometric measurements as the light sources

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"pass through" the atmosphere, especially the absorbing layer (perhaps such sequences already exist). At the expected orbital height, I estimate a 7 km thick layer would subtend ~ 1/2 degree and a given light source would "pass through" it in eight seconds. Attempts to derive a density distribution would require a fair number of points in the "1-1/2 or 2 degrees" (divide by 3 ?) so a frame interval near one per second seems desirable. If operated continuously thru the night passage approximately 100 feet of 16 mm film would be required per passage.

As a crude attempt at spectroscopy, color filters could be used on some of the sequences, without too serious light loss. For example, a Corning No. 5030 or No. 5543 filter would limit exposure to the wavelength range of maximum absorption by NO_2 (light loss may be considerable) and a Corning No. 3480 filter would limit exposure to the wavelength range where O^- absorption is negligible.

Relatively broad band interference filters would be useable on the brighter stars and planets. Direct visual observation through such filters would also be useful, especially if photography is impractical and the astronaut tries to reproduce any attenuation noted by neutral density filters in combination with the same filters and stars used in space.

Photometric observations of some of the "intense" airglows mentioned by various authors would also be very instructive. The increased intensity due to external tangential viewing would help a great deal, and precise height determinations could be made.

It may be useful to ask Glenn and Carpenter to reproduce the dimming (as well as memory allows) by narrow strips of neutral density filters against the star

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field they saw, or to compare the intensity and color changes noted with that thru an absorbing cell containing NO_2. The required thickness is readily available.

Acknowledgments

The author has benefited greatly from discussions with several associates, especially as regards references to sources of upper atmospheric and photochemical data.

Dr. Robert Sherman has assisted in location of data on the absorption cross section of NO_2. Dr. Arthur Cox suggested a number of references and confirmed the author's belief that reasonably accurate photometric observations could be made on photographs of a star field. Dr. Leston Miller has emphasized the importance of even crude control of the wavelengths responsible for exposure. All of the men mentioned above are members of the Los Alamos Scientific Laboratory.

Dr. J. A. O'Keefe of the Theoretical Division of the Goddard Space Flight Center generously discussed the observations of J. Glenn and S. Carpenter, and my hypothesis regarding NO_2 absorption. He has referred me to the excellent articles in "The Earth as a Planet" and encouraged my submission of this letter.

Future Work

I would, of course, be interested in your opinion, and that of other experts in the field, of the above hypothesis. If your group recommends inclusion of such observations on a future flight, we may be able to help on some points in data acquisition. I am sure the project would deserve review and control by a panel of men such as Bates and Nicolet.

Respectfully submitted,

Bob Watt

BOB E. WATT
Assoc. J-Div. Ldr.
and Grp. Ldr. J-16

BEW:jo
Distribution:
1 - Dr. Jocelyn Gill
1 - Dr. J. A. O'Keefe

SGC/pending

In reply refer to: SGC:ML:ml

21 February 1962

MEMORANDUM

Subject: Possible Scientific Visual Information Obtained by J. H. Glenn

1. Two (2) interesting observations were reported in the Press, as described by Colonel Glenn during the MA-6 flight. It is of vital interest to obtain a more detailed description of these observations in order that the accuracy and the details of what was observed may be properly recorded for scientific evaluation. The two observations were:

(a) The report of the great number of luminous particles apparently travelling with the spacecraft at Friendship-7 sunrise; and

(b) The altitudes or angular view of the upper limb of the atmosphere.

2. The thousands of luminous particles were described as travelling with the spacecraft. It is important that Glenn describe in detail precisely the observational characteristics under which he saw the particles in order to obtain an estimate of the brightness of these particles. The questions that we would like answered are what was the basis of Glenn's determination ~~of~~ that the particles were actually travelling with the spacecraft and whether this condition persisted on subsequent orbits. In addition, the geometry of the observations should be further described in order to derive the geometric distribution of the particles relative to the spacecraft's window. (The precise observational time and the position of sunlight luminosity can readily be determined from the orbit of the spacecraft itself). These particles may be geocentric in origin and may be suspended in the atmosphere. There are at least two hypothesis for explaining particles travelling with the spacecraft. The intensity compared to starlight should be determined also as this information is of importance in determining further information about the absolute number and cross-sections of the particles and may relate to the dust content of zodiacal light as well as the gegenschein.

In a similar manner, the observations of the horizon and the extent of the atmosphere are of great interest in determining the distribution of various atmospheric characteristics. The precise lighting conditions regarding the position of the sun and the intensity of the outer edge of the horizon as observed by Colonel Glenn may be used in the consideration of what Glenn actually saw. For example, he may have seen the limit of the atmosphere (based on the 8 degree limb described in the press, the atmosphere apparently extended to over 150 Km) by Rayleigh scattering; he may have seen the airglow; or he may have seen the MIE scattering from dust in the atmosphere. The true limiting angle of his observations and a graph of the intensity drop-off with angle from the earth should be obtained in addition to the lighting conditions.

It is recommended that this information be obtained from Colonel Glenn as soon as possible.

Maurice Dubin
Head, Aeronomy Program
Geophysics & Astronomy Programs
Office of Space Sciences

SG_____ SG_____
Fellows Clark

HAND-CARRY

NATIONAL AERONAUTICS AND
SPACE ADMINISTRATION
WASHINGTON, D.C.

SPECIAL

GPO 16—75511-1

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Dubin

21 Feb

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In reply refer to: SGC:ML:ml

21 February 1962

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SG RFF
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SG J.J. Clark
Clark

MJR

DRAFT OF NOTE ON THE SCIENTIFIC OBSERVATIONS

Toward the end of the flight, between 16 hr and 47 min (UT) and 17 hr and 03 min (UT), 24 May 1962, Lt. Cdr. Carpenter made a series of observations on a luminous band visible around the horizon. The most decisive observation was made with an airglow filter supplied by Mr. Lawrence Dunkelman of Goddard Space Flight Center. The filter transmits a narrow band of wavelengths, approximately 11 Angstroms wide at the half power point and centered at the wavelength of the strongest radiation of the night airglow, namely 5577 Angstroms. The filter cut out all other light, but passed the light of the luminous band, which is thus identified as the 5577 layer.

Lt. Cdr. Carpenter noted that the layer was very bright. He found that Phecda, γ Ursae Majoris, magnitude 2.5 was lost to sight at the brightest part of the layer. Assuming that the image of Phecda occupies about 1 square minute of arc on the retina, or 8.18×10^{-8} steradians, and assuming that a star of magnitude 0.8 yields 10^{-6} lux (lumens/m^2) we find that the brightness of the layer is about 3 lumens/(m^2)(steradian) or 3×10^{-4} stilbs. This is equivalent to about 4×10^{4} ergs/(m^2)(steradian)(sec), taking the least mechanical equivalent of light as 1.61×10^{-3} watts per lumen for 5560 A as per the AIP handbook. It is about 50 times as bright as a white surface illuminated by moonlight.

The angular height of the layer was found in 5 different ways:

1. By direct estimate - 8° to 10°.

2. By noting that it is approximately twice the height of the twilight layer. Lt. Cdr. Carpenter estimated the height of the twilight layer as 5 sun diameters, which means 2-1/2 degrees, hence the height of the 5577 layer would be 5°.

3. By observation of the star Phecda (γU Ma) as it passed the middle of the luminous band.

4. By noting the time when Phecda was halfway from the luminous band to the horizon.

5. By noting the fact that when the cross of the reticle is set diagonally, the horizontal bar just covers the distance from the band to the horizon.

By method 3, we make use of the time of passage through the middle of the layer. This point is marked by a reference to a mark on the telemetering. ~~It is understood that this mark can only be found on the ground station tapes, which are not yet available,~~ and conversation with Lt Cmdr. Carpenter ~~but~~ By careful timing of the capsule tape, it appears to have been very close to a $4^h\ 4^m\ 29^s$, capsule elapsed time, i.e., $16^h 50^m 45^s$. UT. For this instant the capsule coordinates as interpolated from the Woomera tracking data, were - longitude = 127^o 40:0

latitude = -18^o 49:8

height = 226 kilometers

At this moment, the line of sight to γ Ursae Majoris was tangent to the layer of maximum thickness of 5577. The angular zenith distance of γ U Ma at this time was found to be $101^o 42'$. A line of this zenith distance is tangent to a spherical shell of the proper radius which is 137 kilometers below the capsule or 89 kilometers above sea level. Accordingly, this observation should be interpreted as indicating that the densest part of the 5577 layer is at a height of 89 kilometers, which is in good agreement with rocket measures.

The lower limit of the visible light appeared to be near 78 kilometers; but this determination is not considered as significant, since a luminous shell is expected to diminish gradually downward in apparent brightness, even if it is actually very thin.

The upper limit of the layer is at about 105 kilometers, so far as can be judged from the voice tape; this result is quite uncertain.

The filter observation on the airglow was made at $17^h\ 02^m\ 6^s$, UT.

Sunrise was observed at about 1^m later, while the observation was going on. It follows that the airglow is visible even when the twilight band is very strong. An attempt to observe it in the day is certainly indicated. In this connection, it should be noted that Capt. V. I. Grissom reported a grayish band at the top of the blue sky layer. (Results of the Second U. S. Manned Suborbital Space Flight, NASA, GPO (1961). He remembers this layer as narrow and grayish in color, representing an actual increase in intensity. He pointed out the approximate position of the layer on one of Lt. Cdr. Carpenter's photographs at the height of 1.7 degrees above the horizon. Grissom may have observed the daytime airglow.

Carpenter did not note any structures, either vertical or horizontal, in this layer. He did not observe it completely around the horizon but believes it to be continuous all the way. It does not appear possible that this layer can actually absorb starlight. Any layer at this level capable of absorbing a noticeable fraction of the light (25% or more) would also scatter light strongly; it would therefore be a very prominent object on the daylight side. In fact, it is not definitely visible on the photographs of the day side. This is entirely in agreement with Lt. Cdr. Carpenter's impression, namely that the decreased visibility of stars passing through the layer was a contrast effect.

A remarkable feature of this observation is the discrepancy between the eye estimates of 8°-10° for the altitudes above the horizon, on the one hand, and the results of timed observations on the other. The latter indicates altitudes of 2° to 3°. The latter are clearly correct; for example, Carpenter noted that when one arm of his reticle was at an angle of 45°, it covered the space between the horizon and the bright band. The crossarm is 1.21 centimeters in length and it is a distance of 26.2 centimeters from the astronaut's eye. At an angle of 45°, it subtends a vertical angle of about $2^\circ.6$.

It thus appears that there is a strong illusion which exaggerates angles near the horizon, and which was evidently also present in MA-6, since Lt. Col. Glenn also reports 7^{o} to 8^{o} as the height of the luminous band. The illusion is perhaps comparable to the well-known illusion which makes the moon seem larger near the horizon.

Carpenter also noticed and photographed the Glenn effect. He reports white objects resembling snowflakes, seen at sunrise on all three orbits. However, he also saw these objects 7 minutes after the first sunrise and again 43 minutes after sunrise; and 2^{m}, 11^{m}, 23^{m}, 26^{m}, 36^{m} and 45^{m} after the second sunrise. It is thus quite clear that they are not related to sunrise, except perhaps in the sense of being most easily visible then.

Carpenter managed to photograph a few of these particles. Some of them were very considerably brighter than the moon, which was then very near the first quarter. At this time, the moon is about -10; the particles may have been between -12.5 magnitude (10 x brighter than the moon) and -15 magnitude (100 x brighter than the moon). The second is considered more likely, in view of the appearance of the full moon (-12.5) as shown on MA-6 photographs. At -15, the particle brightness is consistent with centimeter size snowflakes. The particles were verbally described by Carpenter as between 1 mm and 1 cm in size, and having a strong visual resemblance to snowflakes.

Shortly before reentry, just at sunrise, Carpenter performed the decisive experiment of hitting the capsule walls with his hand. The blows promptly resulted in the liberation of large numbers of particles. It is thus clear that at least those particles observed in the MA-6 flight emanated from the capsule.

The possibility that the particles might be dye marker or shark repellant, both of which are green and both of which are exposed to the vacuum, was considered by Mr. Frank M. Crichton, NASA capsule inspector. Crichton had tests made which demonstrated that neither material tended to escape from the

package in a vacuum. The possibility that it might represent small particles from the fiberglass insulator was also considered; in view of the smallness of the fibers, it appears likely that they would have been blown away at once, like the Mylar confetti. The dynamic pressure of 1 dyne m^2 is sufficient to remove at once anything weighing less than about 10 to 100 milligrams cm^2; which corresponds to a thickness of the order of 0.3 to 1 millimeter for most ordinary substances.

As mentioned in the MA-6 report, there are two plausible sources within the capsule for these particles.

(1) Snow formed by condensation of steam from the life-support system.

(2) Small particles of dust, waste, bits of insulation and other sweepings.

The latter are very conspicuous in a zero g environment, when there is nothing to keep them down; it is found to be extraordinarily difficult to free the interior of the capsule of such material. Undoubtedly, the exterior parts of the capsule which are exposed to the environment will contain these things, and they undoubtedly play a part in the Glenn effect. In particular, a corkscrew shaped piece observed by Carpenter was probably a turning or perhaps a raveled piece of insulation.

On the other hand, there is considerable evidence which points to snow as the source of the majority of the material. In the first place, water is dumped out of the capsule in far larger quantities than any other substance. In the second place, the material looked like snowflakes both to Glenn and to Carpenter. In the third place, the frequency with which the Glenn effect is reported by Carpenter appears to be correlated with the temperature of the exterior of the capsule as recorded by thermocouples in the shingles. The temperature was always lowest at night, falling to temperatures of -35°C just

before sunrise, and rising to plus 10°C just after sunrise. During the second day, the temperatures were lower, reaching about -25°C during portions of the day. From about $3^h\ 30^m$, CET, on the second period of sunlight, the temperatures were higher, and only one particle is mentioned.

If the effect is indeed due to condensation of moisture, then the broad end of the capsule is a more likely source than the narrow end, because the temperatures were 20°C or more higher at the narrow end.

The condensation probably took place inside the capsule, rather than outside, because even at the lowest recorded shingle temperature, around -50°C, the vapor pressure over ice amounts to about 0.039 millibars. Although this pressure is very low, it greatly exceeds the ambient pressure at the lowest capsule altitudes. Accordingly, it is not possible that snowflakes should form under these circumstances, even though it is true that the capsule must be surrounded by an expanding atmosphere of water vapor.

If the water-vapor expands freely, it is clear that the pressure at a distance of 1 meter from a hole 1 cm in diameter will be of the order of 1/10,000 of the pressure at the hole. Hence it is fairly clear that the pressure inside the capsule will be far higher than the outside pressure, in spite of the presence of 18 one-centimeter apertures. Hence condensation within the capsule is more likely than condensation outside. It is noteworthy that no formation of rime was noticed either on the window or on the balloon string. It is considered most likely that the particles of the Glenn effect are snowflakes formed in the capsule, between the cabin bulkhead and the heat shield by the steam exhaust from the life-support system. It is suggested that they escape into space through the porte, being driven outward by the expanding vapor. Note that at 02 52 47, Carpenter noted a particle moving faster than he. At 02 50 00, he planned to observe sunrise and was facing forward. This particle was thereby probably seen east of him. Most of the particles are seen behind him and falling

back. This supports the idea that the particles probably are pushed outward by the expanding steam from the capsule, before they begin to stream backward. It is probable that many of the particles lodge on the outside of the capsule, since Carpenter is quite sure, from the direction of streaming across the window, that the particles came from a point near where the knocking was done.

Carpenter obtained two excellent photographs of the sun when just above the horizon. These photographs plainly show the flattened, sausage-shaped form photographed earlier by Glenn. Carpenter notes that what he saw was like the photographs show with the exception of some reflections at the corners Calculations of this theoretical shape are being made at this time for comparison with the astronaut observations. The flattened shape is due to the fact that the lower portion of the sun's disk is seen through layers which refract the light much more strongly than those through which the upper part is seen. As a consequence, the whole disk appears flattened. A similar, but much smaller flattening has long been known to be observable from the ground. A part of the interest of this phenomenon comes from the fact that at great distances, as at the moon, the effect of this refraction is to make the sun appear as a red ring of light around the earth.

Dr. M. Dubin
NASA Headquarters
Code SG

SCIENTIFIC DEBRIEFING

June 1, 1963

(First Experiment - Flashing Light)

John McKee: One of the first questions that I have regards some estimates you made of the beacon distance. Were those based entirely on the knowledge of how bright it was from previous aircraft training or do you feel there was some other distance cue somehow involved in the test.

Cooper: No. If I had no previous experience on the light, I don't believe I would have had any possibility of telling how far it was except that on that second night pass after ejecting the light. Apparently the sun was shining on it as I saw this steady glow, up to about my level on the orbital path. At that time I had a little bit more depth perception on it and could seem to note the proper drift on it. That was the first time that I saw it. Other than that, it was pretty well related back to what I saw in the planetarium and to the experiments we did on the aircraft when we had radar measurements.

McKee: At the time you deployed the light you said you felt it deploy; did you notice the pitch rate? -- or what was the sensation?

Cooper: No, I didn't notice any rate as such. I could really feel it in the spacecraft and to me it felt just like there were doors banging open down there as it departed and just a little bit of a jolt through the spacecraft. It was a good solid thump when it took off.

Bill Armstrong: Actually Gordo, it turned out, it gave you about a half of a degree per second in the opposite direction. This was very apparent on the postflight record. You can see your thruster action when you start to pitch up and then as you come right to the bottom of the curve you can see this little blip on your rate; and then the attitude started back the other way. It was real definite. Something on the order of a half of a degree per second, or a little more. It was real definite where it occurred. Well what it does is start your pitch back the other way. If you remember, you never did use any thruster action to go back in the other direction, to pitch back down after you deployed. You went to cage - to retroattitude and the attitudes just go and start back over. It was real clear on the records where it went out.

Shepard: Say, in regard to the first question, do you think because you had the earth as background you could judge distance, because you had earth as background?

Cooper: I think possibly so. Of course it's like an airplane when it's a considerable distance out. It is almost impossible to judge the distance away. You can talk yourself into believing it is almost any distance from you. And when it gets on in closer you really have a bit more perspective on it. I did feel that I had almost judged the distance on that first try. In fact I didn't even believe that was it when I first saw it. I couldn't think of anything else that it could be but it was just solid light. And as it turns out looking back now on it, I am sure this was because the sun

had not completely set; I'm sure my retro pack area was in the sunlight. I'm sure that is what I saw glowing,--was the sun reflecting off of it. Although I had not seen it from previous viewing on the day side or the night side.

McKee: When you didn't see it on the first night side, did you have any personal feeling that the light wasn't flashing? Did you correct your attitude when you didn't see it or did you have any feeling what the problem was?

Cooper: I just don't have any idea. I kept doubting myself. This was the first time of course that I had ever tried aligning to small end forward, a 180° yaw as wel call it and of course aligning on the night side. I began to doubt that I was aligned properly. I went to the star charts and rechecked and found in fact that I was not quite aligned correctly at first. But then I did double check and found that I was --- I'm sure several times thru the night I was aligned exactly on and in using the horizon line just about in the middle of the window even moving up and down almost invariably. I just don't have any idea why I didn't see it.

Bill Armstrong: You did change your attitudes? That was one of the things I wanted to Know. Do you remember at the beginning of the night phase, did you first start looking low and then toward the end look high or did you just sort of scan the area or what?

Cooper: Well first I started trying to get my 180° yaw point. This is not the easiest thing in the world to get on the night side, and particularly when you have to go into your star charts 50 minutes ahead of where you had normally been used to using them. I finally did find star patterns that gave me the proper orientation. I was using, around 15 to 20 degrees pitched down, I was just keeping the horizon in the sort of bottom part of the window and I got around this area, I then tried varying the attitude up and down to look for the light.

Shepard: You mentioned in your report that,--you talked about approximately 25 minutes after you caged your gyros, that you saw a lot of lightning particularly in that area.

Cooper: Well, this is one possibility that there was a slight compromise to the light. Particularly on the first night side there was considerable large lightning down there. I found concentrations of large thunderstorms right up in there and saw quite a lot of light flashing through fairly large areas. I still don't believe that even on the other night side, in spite of these I still could see the light even with this as a background. It is really not an excuse for not seeing it and I really honestly can't say why I didn't. I had begun to doubt that it was really flashing.

McKee: Was the moon ever a problem?

Cooper: The moon was probably ideal. It was down to about a third moon. It was a very distinctive moon when you could see it but it wasn't causing the great amount of light that a full moon would have caused. I could see the glow on the ground, on the clouds and on the land, from the moon. It was not enough to obliterate all the stars, or when the light was sort of in the direction of the moon. It didn't matter. Q. Was the light ever close to the moon? A. No, the light was never close to the moon. The moon came up just at the last part of the night. It was never close to the moon because the moon was just coming,-- the moon came up just at the last part of the night. It had not been up very long before, before I began to get daylight.

Bill Armstrong: This is a real puzzler. We looked at the temperature traces in the retro pack area; they ran cooler, this flight. Around 60 or 62 degrees. Bill Carmines said that they had actually flashed the light at this lower temperatures without any problem. He talked to Langley people and he says that if the light had failed to work the first time it would have never warmed enough later in the flight to start flashing. It is hard to visualize it not having been working the first time and then worked the second time. Do you think your attitude ---- could you tell any difference in your attitude the second night when you saw the light. In yaw as compared with the first do you think you had your yaw pinned down better then?

Cooper: Well, not really. As I went into both night sides I could pretty well estimate 180° yaw. The first night side I was not completely around. I started yawing around and night was suddenly upon me and I wasn't quite in the full 180° position, so I did have to hunt for the 180° position a little bit. On the second night side after I ejected the light, I was already in my 180° position before going into the night side.

Mercer: How high above or below horizon line or window did you look for light? In other words how far down or how high did you go with your pitch attitude?

Cooper: On the first night side I allowed it to drift very, very slowly and changed them as I needed to, very very slightly to keep my yaw on 180° and it varied back and forth very slightly. But I went all the way down to where the horizon would fill the whole window and up to where I just barely had the horizon in sight.

Bill Armstrong: Did you see it come right away when you looked on the second night?

Cooper: I just barely got into the night.

Bill Armstrong: In other words you picked it up right away?

Cooper: Almost. Almost as it began to get dark. Of course it gets dark just like that. Zam it gets dark. I had just,--it was dark earth background and as I say my first feeling on seeing it was definitely coming from below very very slowly. As I watched it was getting higher in my line of sight to the earth. In other words as I was holding the earth on a fixed place on the window this was coming up. It was coming up in relation to me, and was finally up to my level. And as I saw it coming up it was solid light. My first though on it was that it looked just like the missiles that I have seen launched at night from Cape Canaveral; when you're flying at night at a high altitude and see them launched. It didn't have the same glow but it was very very bright, and solid and seemed to becoming up.

Bill Armstrong: That is something else we checked into. It would have been impossible for this light to have been steady for you. It is necessary to fully charge the condenser and then get a quick discharge.

Cooper: That's why I think it must have been the sunshine on it from behind. Because of the altitude we were both at, the sun would be shining on it at that point. I had just gone into the night side. Even though it was dark if I had yawed around to zero yaw it would have been in the bright sun.

Bill Armstrong: Was it above the horizon when you saw it flashing or was it still in the haze layer, or what?

Cooper: It was just still slightly below the horizon. It had come up almost to the horizon. It had been a fair amount below it when I first saw it. In fact I was pitched down to about -34° and I saw it towards the bottom part of the window when I first picked it up. By the time it got up to where it was maybe 15 degrees higher (in relation to me and my line of sight), I suddenly saw it flashing.

Bill Armstrong: That's just where it would have been. If would have been just coming to the horizon.

John Boynton: Was this predominantly above the horizon?

Bill Armstrong: In the first orbit, no. On the first orbit it is very low. That is why he might not have seen it the initial part of the orbit. Somewhere about 20 or 30 minutes thru the night side, it passes through the horizon and then it goes about 25 or 30 degrees high. It goes through a fairly large angle change at first, and the further out it gets of course the smaller the angle change is. The second night after deployment just about at sunset it starts up through the horizon and then all the time during the second night phase it is above the horizon. Then the third one is above the horizon all of the time.

John: If he is at zero roll what is the maximum visual angle of sight through the window?

Bill Armstrong: You get a 30 degree angle view through the window. From the top of the window to the bottom, $30\frac{1}{2}^{o}$. You can see over an elevation variation of 30 degrees.

John: How far would he have to pitch down?

Bill Armstrong: He would probably have to be below retroattitude. He had to almost have all earth in the window. Probably about 30 degrees.

Cooper: I had a few comments that I made on the onboard tape about the light: "I am at last daylight going into dark" I had been looking for that flashing beacon. "This light in sight is below me. It is quite a brownish reddish brown and considerable altitude above the ground." In other words I was convinced it was not a light down on the ground but it had movement. I mentioned several other items here such as this light being visible among the stars. "The light is flashing, now. It is the light. It is quite bright and quite discernible. It appears to be about 10 to 12 miles away. I'm keeping it exactly in the window. About the order of a second magnitude star now." and that time was 05:11:34. "The light is still in sight in the center of the window."

Bill Armstrong: Did you,--according to the voice tape it indicates that you may have yawed away a little bit then and then came back. Is that right? Did you yaw away and then come right back to it?

Cooper: Just once.

Bill Armstrong: Did you do it twice or just once?

Cooper: No, I kept it in sight for quite awhile and then yawed away from it and then came right back.

Cooper: At 05:13:40 I made some comments on the Milky Way and various things and at 05:16:35 the light was still in sight. Thunderstorms were in under it at the moment but it was still quite distinctive. And this is at 05:18:05.

Bill Armstrong: What brightness do you think you need if you are going to try to acquire some target in space.

Cooper: It was very distinctive both times. At this brightness where it was on the second night side after the ejection, both times it was very distinctive more than the brightness of course, it was the flashing. On the third night side it was extremely faint but the flashing allowed me to pick it up. I wouldn't have been able to see it the third night but for the flashing.

Bill Armstrong: Do you think that either at the initial acquisition of the thing or even toward the end of the second night phase the brightness would be sufficient if you would be trying to locate a rendezvous target?

Cooper: I think so. I think with that brightness, if you know approximately where to look for the thing and with it flashing, you certainly ought to be able to find it pretty readily.

Day: Do you think similar experiments should be carried on or is this sufficient?

Cooper: I think this probably shows us what we really want to see. I think there is going to be problem like there is in aircraft. As you move in closer to it you are going to have to have something that gives a little bit more capability to obtain distance from it at the time; such as perhaps two lights that you could range on; like navigation lights on aircraft.

Question: Were internal lights on in the night observations?

Cooper: On most night sides I had all the lights down completely and used just the glove lights to read critical items.

Bill Armstrong: On the third night phase you say you had to do a good bit of searching. Were you searching the entire third night, and when did you first see it?

Cooper: Slightly past the middle of the night. I think that on the third night side the brightness was such that it was sheer accident that I found it. If you just happen to pass it in the scan pattern you might see it flashing. It would, however, be very easy to miss.

Bill Armstrong: You feel brightness suitable for a rendezvous target would be something on the order of second or third magnitude.

Cooper: Yes.

Bill: That's one of the main things we wanted to find out. Does the brightness of the second night look about right? Was the third night too dim?

Cooper: Yes, the third one is getting a little too dim.

Bill: Do you think you have got to have good sighting information to pick these up even with bright light?

Cooper: Well, it is a pretty big sky at night up there and there are a lot of bright stars. I think you're going to have to have some sighting data to get within a reasonable cone area to hunt for it.

McKee: What about the flash frequency rate?

Cooper: I think the flash rate could be cut down. I think you could maybe halve the flash rate. I would rather see it twice as bright and see it flash half as often. A flash rate, even one every two seconds is still distinctive. Maybe not quite as distinctive as the one per second, but it still would attract your attention.

Bill: How about the deploy marks?

Cooper: Those deploy marks worked real well. They were excellent for getting in retroattitude also. They position your head to a real positive position.

Bill: We have read the attitude records pretty carefully. You were between 20 and 22 degrees, so you were right in there. Do you think the window smudges, the discoloration of the window, might have had significant effect? Do you think it produced enough attenuation to cause any trouble?

Cooper: Actually I tried and tried to note how much attenuation you get at night. It's just a few seconds until the time you get dark-adapted; I thought you became dark adapted very rapidly, and I didn't see or note any real attenuation. I am sure there was some as there was definitely smudge layers there. But it didn't seem to be.... The bright stars sure seemed bright.

Bill Armstrong: Did you actually see the light against the ground?

Cooper: Yes. I made this comment here that I even saw it against the thunderstorm.

John Boynton: Gordo, you talked about the flash rate. The flash rate in your debriefing might have been slightly below a flash per second.

Cooper: I did it on the tape. I counted off here on the tape so you could get it off the tape. I counted 1,2,3,4,5,6,7. It seemed to me that it was slightly slower than one flash per second.

Question: What did it check out?

Carmines: 62 (flashes per minute).

Bill: Did you make attempts to see it on the day side?

Cooper: I sure did. I never saw it then.

Armstrong: It should have been closer on the day side than in the night portion. It came in closer and started out away some time during the first day pass. Before you picked it up it had started out again. It should have been in to about two miles sometime during the first day side.

Cooper: At first I was on 180 degrees yaw, and allowed it to drift off. I didn't find it, but before I got to the next night side, I brought yaw back to 180 degrees. There was a possibility I missed it there.

McKee: Did the flash seem very consistant? Did the brightness vary?

Cooper: Yes, it seemed to be very consistant.

Carmines: Did you see it tumble?

Cooper: I couldn't tell any tumbling.

Carmines: I'm sure it was tumbling.

Bill: The spread of light isn't too great.

Cooper: It is pretty hard to judge the light level.

Mercer: Did you see the stars during this day?

Cooper: Not this particular orbit. No I didn't.

(Second Experiment - Balloon Drag)

Day: Mr. Carmines will you give us a quick run-down on the balloon experiment failure?

Carmines: I talked with Instrumentation people and everyone agreed that we really don't know what happened. We had one relay actuate. There are several possibilities. To me the most likely place of trouble is the final plug. The pins are on the pigtail and in putting this together you can bend these pins and get a misalignment. We checked the plug and in this case the pin is near the case and if it bent it could ground.

Bill: The squibs were in parallel and a number of tests showed either one of the squib would fire the latch. The most probable cause is in the circuitry.

(Discussion on Ground Light Observation)

Bill Armstrong: How hard was it to pick up the light when you first started. Did you have trouble picking up this ground light at all?

Cooper: No. It was just a bit further to the left than I thought it would be.

Bill: More toward the center of the window?

Cooper: No. More slightly to the left of the window. I could have been yawed off a little. I thought the pattern of the little town, it was by was really more distinctive than the light. If I hadn't known the light was there I wouldn't have selected it in preference to lots of other lights I saw on the ground,---if it hadn't been for the little horseshoe-shape town.

Bill Armstrong: What brightness did you see at this attitude?

Cooper: I would say it was about between third and fourth magnitude when I first saw it.

Bill: As you continued to observe it did you notice it dimming?

Cooper: No. I could see it for several seconds. One falicy of the ground lights is that you are moving on the ground pretty rapidly. You don't have many seconds to observe any fixed points on the ground. It's moving right on past you and gone fairly rapidly. Of course as it gets on out it gets dimmer and dimmer.

Question: Have you any idea how long you <u>were</u> able to observe it?

Cooper: Maybe as long as a minute. I doubt if it was that long, probably 30 or 40 seconds. I lost it because it got too weak. It was a long ways from being straight out on the horizon but as it got on up towards that direction it faded out.

Bill: In checking the plot, it looks like it varies from a little over second magnitude when you forst saw it to about a sixth magnitude when the light was turned off.

McKee: Do you know what angle you pitched down to?

Cooper: I believe it was to -40. I was then at the angle we were supposed to pitch to. I apparently had eased off in yaw. However it tracked pretty well right up the window. So the yaw was fairly well on. But the light was off a little further to the left.

Bill: Did you ever look away from the light and then look back? Were you able to do this and pick it up again?

Cooper: I took my eyes off of it and had them on the photometer and looked through the hole in it and extincted it. Turned the dial the wrong way in the dark, and I did extinct all right. I thought I'd get a good reading on it. I gave that device up. It did extinct.

Bill: Did you ever notice any change in the light?

Cooper: Yes, it got dimmer.

Mercer: Could you see lights of cities through layers of clouds?

Cooper: I saw a lot of cities underneath the clouds. One of my best retrofire yaw alignments was over Shanghai.

Mercer: Were light patterns more distinctive than individual bright lights?

Cooper: Yes. I was over the east coast of Australia. I saw three very distinct city light patterns there around the Melbourne area.

Paul: When the light dimmed out did you lose the light first, or the cities?

Cooper: I lost both in much the same period of time.

Jones: Did the ground-light appear sharp as a point source or was it diffused?

Cooper: It was more diffused. Not a sharp point. You could see it was a single light but it was not like the stars.

Smith: You think a flashing light would be preferable?

Cooper: Definitely: The ideal would be a series of lights. A better combination would be a series of flashing lights arranged in some pattern. Maybe like a running rabbit strobe pattern. I am sure it wouldn't have to be synchronized.

Bill: You mentioned how fast fast you were moving. Do you think you had enough time to make use of some sighting device such as a sextant?

Cooper: You aren't going to be able to take very long readings. You're going to have to be set up and ready to go, and you're going to have to have some devices that are really usable. You figure that when you get from the west coast of the United States to the east coast of the United States, the ground is moving under you fairly rapidly in ten minutes. The ground is moving too fast. You need to have some devices that are really usable and you need to be set up and ready to go. I guess you have about 20 to 30 seconds for a reading.

Bill Armstrong: One of the phases of the Apollo mission requires a position fix while still in a holding orbit. Before going into the translunar phase sightings of earth fixed targets for navigation would be about the same as you experienced in the ground light. Would this be practicable?

Cooper: You're going to have to be right on in attitudes. You're going to have to know exactly what time it's going to occur. I'd guess you have about 20 to 30 seconds to do your actual sighting and you have to have a good angle off to do it.

Bill: How about the brightness Gordo? How do you feel about this part and leaving the flash part out of it? Was it bright enough light to be seen easily?

Cooper: There were a lot brighter lights on the ground.

Bill: I'm sure of that but do you think this is sufficient?

Cooper: You can see it. If you look for it and know it is there and if you're lucky. Knowing where to look for it and no clouds there, you can spot it. (And away from other background lights.) I still think a pattern would be better than going to a brighter light. I don't think the change in the brightness of the light would be as effective as making some kind of a pattern.

Jones: Did the ground lights twinkle?

Cooper: Yes. Just like the stars do looking at them from the ground, where as the stars don't twinkle there.

McKee: I would like to ask. You seemed to have seen our lights as we expected. You saw some objects on the ground better than we expected. Can

(McKee continued) you say why you saw such small items?

Cooper: I was coming from Houston the other day in a 102 and I noted I couldn't see nearly as clear around 40,000 feet, particularly in one area that I was in. There was a lot of haze and it was quite humid and I couldn't distinguish things on the ground very well but yet when I got into the west coast of Florida and got into an area that was somewhat clearer, at the same altitude I could see many things. I think again, that it depends on how much humidity you have and how much haze is in an area. I passed right over the vicinity of Los Angeles and San Diego and never saw them at all. I wasn't very surprised. I could see where they were but I couldn't see them. I passed right over Miami and Miami Beach and I could see that there was a town there. There was a lot of build up and civilization. I could see the streets but the buildings were not very distinct. But yet over areas of El Centro and the Salton Sea and the dry lake areas I could see tremendously greater detail, and individual roads. Over the Himalayas, up in Tibet, of course there you're above a good portion a certain amount of the atmosphere I suppose, I was really surprised what I could see. I found some real details and little villages with maybe 20 or 30 houses I suppose, stood out very distinctly. You could estimate the number of houses and if a house was out individually away from anything else I guess against the right color background, the yard, I could discern individual buildings. I saw a number of them with smoke coming out of the chimney. There was snow on this upper very sandy blowy, dusty Tibetan area. I could see a lot of lakes some partially frozen over and some frozen solid. The visibility was tremendous. I could see vehicles that I assumed were trucks. I could see them kicking up dust.

(MIT Horizon)

Dr. Peterson: The purpose of these pictures is that we are trying to find definite information about the earth for Apollo guidance. This is one of a group of four pictures taken in four different yaw directions, one into the sun. Is this maneuver an expensive and troublesome thing to do?

Cooper: It takes control power; it takes control fuel, it takes time. However, it is not real expensive as far as fuel. You have to stay power up. We debated back and forth about the most accurate way of making sure we get these 90° points. We were a little concerned about accuracy and decided to stay powered up and utilized the gyros to locate the 90° positions. But it does take that period of time of power to drive the automatic system, and it does take that fuel to move around.

Dr. Peterson: I noted you mention 25 hours 20 minutes. At that moment there is a hole in the transcript. 25 hours and 26 minutes.

Cooper: I got those at 25 hours and some odd minutes when the moon was set in the west. It was right where we had planned to get it the first time. We rescheduled them later in the flight if we didn't get them at the original time. But I took them as planned initially. Did those come out all right?

Dr. Peterson: On two of those it was possible to locate the moon. This is not all of them.

Bill Armstrong: Yes, these are all of them. (Looking at pictures)

Dr. Peterson: There is a smudge in the middle of the window. It could have been accidently concealed. Since these negatives are only suitable for microdensitometry there doesn't need to be any discussion of the details of their significance.

(Infrared Weather Photographic Experiment)

Mr. Day: I would like to move on to IR Weather photography.

Soules: This experiment went very well and we got the information we wanted. Thank you very much. Did you have any trouble with the camera or filter holder?

Cooper: None at all. It worked very well.

Soules: And the lens opening of 5.6?

Cooper: It was exactly-on what was marked on the magazine.

Soules: There are six pictures at the end of the series and I can't identify them. Do you have any idea where they could have been taken?

(There was a lot of table discussion of pictures here)

Cooper: This was after the Florida series.

Soules: You made the remark that you were coming over Africa. Do you have any more information? There was none in the transcript.

Cooper: What base was this on?

Bill: Wasn't one of them over the coastline?

Cooper: Yes, I did one right on the coast of Africa. I got one coming right over the coastline. Another one I got almost over the other coast; down toward Johannesburg; it was an inland picture, almost the northern area.

Soules: The last four are a mystery.

Bill Armstrong: It looks like you had about a quarter inch motion on frame.

Cooper: I'm sure I didn't. I was holding the camera just like I was before.

Soules: We might check the camera.

Soules: What was the dominant color of the earth over Baja California?

Cooper: I found that the green showed up very little. The only really distinct green that I saw which showed up much was in the high Tibetan area. It was a bright emerald green, by some of those lakes. It looked like a copper sulphate mining area. The browns of the Arabian Desert Sand showed up quite distinct. The Sahara was not quite so brown although it did have

(Cooper continued) a brown look. Everything predominantly had a bluish cast. All the water, all the sea water, looked very very bright blue. Even the Salton Sea looked very blue. And areas we know were heavy forest areas looked kind of blue-green. The areas that are definitely brown you can tell they are brown.

Soules: I have a question on the thunderstorms. Could you hear static?

Cooper: I could hear it day or night and on both HF and UHF. It was almost instantaneous. As I would see the lightning and the clouds light up I would get the static.

Soules: What is the frequency band on HF?

Cooper: HF is 15 megacycles. The static was louder in the HF than in the UHF. You could just hear it, it wasn't high magnitude.

Soules: Was there a difference in loudness between day and night?

Cooper: I think night side was considerably louder. Of course I noted thunderstorms were louder on night side. There were large masses of thunderstorms out to the east of Australia.

Soules: Did the flash come from below the capsule or could you look off at an angle?

Cooper: I could not see distinct lightning patterns. It just all lit up. The whole cumulus mass of clouds would light up.

Soules: Did you notice thunderstorms between Hawaii and California.

Cooper: Yes, several off the west coast of the United States. I don't remember just how far. There were several cumulus buildups.

Soules: Did they look like the usual thunderstorms?

Cooper: They went on down to a stratus deck on into coast on down about Los Angeles. They stood further off the coast than up north.

Soules: Did you see any long white bands of clouds along the east coast in the tropical areas?

Cooper: Yes. One was over the Arabian desert that was quite distinct. I took a color photograph of that.

Soules: Was it a very sharp line of clouds with build-up in it?

Cooper: Yes. Number 10 picture is over the Arabian desert area.

Soules: Over the oceans did you notewwide bands with perhaps clear area over it?

Cooper: No. I noticed several large cyclonics. I did not notice any very distinct sharp bands. However I did notice tropical thunderstorms. Near the Solomon Island Areas there were a lot of low streets and ridges of smaller cumulus clouds. There were little rows of them.

Soules: Was the horizon always a sharp line?

Cooper: Yes, day and night the horizon was sharp. In the day you have this bright blue band around it.

Soules: Some photos show the horizon seemed fuzzy.

Cooper: In the Himalayas on a couple of occasions where the horizon was rough due to the mountains, the horizon was still very distinct.

Soules: Did you see the moon at the time of occultation?

Cooper: Yes, several times. I was sorry I did not get pictures.

Soules: Did you see a halo around the moon?

Cooper: I saw no sign of a halo. It was quite sharp.

Soules: Did you ever see a slight flash? Did the moon's color change at all as it went through the atmosphere?

Cooper: No. I was looking for this too. I was disappointed in the moon scenes. I didn't see anything distinctive at all.

Soules: I made a sketch of haze layer. Would you take a look at it and tell me what you think?

Voas: Gordo, would you draw it on the board?

(Period demonstrating on blackboard of horizon, haze, etc.)

Cooper: This is the earth with a sharp horizon on the earth. The lower haze level was always under me separated from the horizon. This was not a real distinct line. It was a little more distinct and it appeared to be the same color as if it were a cloud and as the stars would pass down through it you could track a fairly high order of magnitude of star and you could track it down through haze and it would appear real bright as it came down through it.

Soules: About what magnitude could you see?

Cooper: The stars in the Big Dipper could just be seen. I noted the Big Dipper with the bottom star sinking down into it.

Soules: The top of the layer would be how many degrees above the horizon?

Cooper: I figured it was about six or seven degrees.

(Long period of sketching.)

Peterson: Would you estimate any appraisal in terms of stellar magnitude? You explained that the fifth magnitudes could be seen, did the weaker stars go out in that area?

(Still illustrating.)

Note: During this period when Cooper was talking and sketching on the board, the recorded comments are meaningless.

Cooper: I can't recall a single time at night but what I saw the haze layer.

Dr. Voas: I described the earth as being dark. Which is darker, the earth or the little band of sky?

Cooper: When there was no moon the earth was darker. In general there was more light from the sky. It is a difference in two different blacks. The sky is a shinier black. The earth is a dull black.

Dr. Voas: The horizon is very well defined?

Cooper: It is actually a different black. There is a distinct line of horizon and the earth is darker. This is in complete night.

Dr. Voas: When the moon comes up the earth becomes lighter as the moon shines on it?

Cooper: It shows up distinctly, especially when there are clouds.

Soules: Here is a picture that Wally took. Does that look like a haze band on the horizon?

O'Keefe: When was that picture taken?

Soules: Is that too high?

Soules: You saw something over South America?

Cooper: Yes, there is this other higher level I saw over South America.

Stanley Soules: Did you see different cloud layers at night?

Cooper: Only if there was moonlight and if there were towns or cities below them. On several occasions I could see reflected light particularly through stratus type clouds.

Soules: You could distinguish clouds. Does the earth appear as blue to your eye as it does in the photos?

Cooper: Yes. The overall color is pretty blue.

Soules: What is the color of the twilight zone?

Cooper: It is a baby blue. It is a pure, pure blue, very, very bright.

Soules: Did you see any meteor trails?

Cooper: No.

Soules: Did you see a lot of sun?

Cooper: I sure did. I want to tell you I did!

Soules: Was there any evidence of a corona?

Cooper: No. In fact, the sun appeared to be like the moon does from the earth. Very bright. You know down here there are all those rays around it. But up there it is just a glob and it is very very whitish bright. It doesn't look the same color. It is a very arc-like color, bluish white.

Question: What about the looks of the day sky?

Cooper: The day sky just is not as dark as the night sky. It is black and dark but not as dark as the night sky. You can see the brighter stars on the day side when you are away from the sun and neither it nor the earth shine are coming in the window. Give yourself a few seconds to get dark adapted and you can see the brighter stars. They have to be fairly bright to see them. On the order of 3rd magnitude.

Dr. Voas: The day sides get a lot lighter, at night they are about the same darkness as the inside of the spacecraft.

Cooper: The night sky and the day sky is about the same as the difference between a jet black and a dark gray. (It is about the same difference between the night sky and the day sky.) It is a softer kind of dark during the day. Not nearly as dark as the night sky.

Dr. Voas: Is it a smooth overall gray on the window? Do you see any chance at all that the grayness you noted could be minute amounts of scattered light from fog on the window?

Cooper: I don't believe so, Bob, because immediately when you got a faint amount of oblique light on the window it immediately looked like it was iced over. All you had to do was get just a faint amount on it and it appeared to be just like a canopy frozen over.

O'Keefe: Was this scattered light in the window or not? I hoped you could see some kind of a pattern.

Cooper: That's what I'm saying. When you have any kind of scattered light on the window, when the window was in any kind of an attitude (demonstrated) say this is the window and out here is the sun, any time the window was moved around where there was any kind of light shining on the window - just a faint amount of it would completely obliterate the vision through the window. I just went completely IFR. There was just no looking through the window. Of course, the earth gives off an awful lot of light, and you can't see anything as long as the earth is shining in the window. Any time the sun was back here and I was faced away from the earth, regardless of attitude, the sky appeared to be a smooth gray.

O'Keefe: You could see the grit on the window?

Cooper: You could see the light actually impinging on the window. You could see the scum all over the inside of the outside pane.

O'Keefe: Somewhat of a pattern?

Cooper: That's right. A pattern over the outside of the window as well as the scum on the inside.

O'Keefe: If this had been scattered light you would have had this pattern?

Cooper: That's right.

(Dim Light photographs.)

Day: Presentation of Dim Light Phenomena: Roach, O'Keefe, Huch.

Roach: You had above this haze layer another layer. Would you sketch that?

(Illustration.)

Cooper: This one time I did have it. I am almost certain this was about 24 hours and 30 minutes over South America. I was facing to the east and was on drift, I think. I was looking to the east, northeast area. I was in full drift.

O'Keefe: Reference was on page 26.

Cooper: That was the luminous activity on page 37. "Right now I can make out a lot of luminous activities in an easterly direction." This was at 05 11 34 and on a 05 13 40. The Milky Way was quite distinct. This particular time (over South America) I couldn't make out on this layer. I wouldn't say it was much like a layer. It wasn't distinct and it didn't last long; but it was higher than I was. It wasn't in the vicinity of the horizon and was not well defined.

Roach: More like a patch?

Cooper: Smoother. It was a good sized area.

Roach: You didn't feel this had a discrete shape?

Cooper: It was very indistinct in shape. It was a faint glow with a reddish brown cast.

Roach: Because of your altitude or what?

Cooper: It wasn't so distinctive as to move back on to it. It was very faint and definitely lighter than the sky. It was picking up some light of some type. It was light in contrast to the sky.

Dick Day: Could you see this better out of the corner of your eye?

Cooper: Yes. Sort of that type of thing. I'm almost certain that this was over South America, just coming up on to the northeastern part of South America. It was around 50 degrees West and about zero degrees of latitude.

Roach: This reminds me of what Mr. Schirra saw off Madagascar.

Cooper: He saw it off North Africa. It seemed to be quite extensive but not well defined. It was rather diffused but not covering the whole earth.

Roach: Could you tell us what happens when you pass from day into night, around twilight? We are interested in horizon effect after sunset.

(Cooper draws some more pictures.)

Cooper: You never tire of looking at the sunsets. As the sun begins to get down towards the horizon it is very well defined and not diffused as it is when looking through the atmosphere, and it is quite difficult to look at. It is quite white and as it gets on down to where the sun begins to impinge on the horizon line it does give a spreading effect. The sky is getting quite dark here and you get the impression of blackness up here. (Illustrating.) The layer is bright orange color and light spreading out in this direction. . .
As the sun begins to go down it is replaced by this bright gold orange. It extends out for some way. It defines the horizon line fairly well at this time. The sun does begin to get this flattened effect.

Roach: What was it's maximum flattening?

Cooper: I never got too much. It appears to get down part way below the horizon

and spread. It doesn't take long. As it goes on down you still have this orange right on the horizon and this area is all considerably lighter although black is coming on down. You do get glow up off it. You could actually swing away and tell right where the sun had set a number of seconds after. It is not ray-like. It is hard to describe. The sky area is lighter but there are not any rays.

Note: At this time there was a general discussion of the night sky immediately after sunset. The transcript is too incomplete in this region to give a recorded account of this discussion. It appears that after describing the sunset and the airglow layer someone Ast. Cooper an additional glow extending vertical above the position on the horizon where sunset occurred. Obviously reference was being made to observation of the Zodiacal light.

Cooper: That's right. After this effect disappears (glow of sunset) and you think you're on complete darkness, I would guess on the order a minute after sunset, you get this other. I guess two different times I saw faint glow but not very far along. It was more on the order of 3 to 4 degrees farther on _____ and a fainter order.

Roach: Did you notice this was cone shaped?

Cooper: A little bit cone shaped.

Roach: Did you happen to sweep across it that way?

Cooper: It was a minute or so prior to sunrise and I moved back across and about the time I got back the sun was there.

Roach: Did it seem to be confined in your window?

Cooper: Yes. The bright blue band grew wider as you moved away.

Roach: Was this just before sunrise?

Cooper: The sun is getting ready to come up and at this particular time I got this glow prior to getting a blue band and in a few seconds the blue widens and widens.

Roach: Is this phenomenon very close to the sun?

Cooper: I had the feeling that this was just a glow off the sun. It was not as bright as the Milky Way.

Mercer: Was it tipped to the right or left of sunrise?

Cooper: I was sitting tipped myself and don't remember which way it was. I have the impression it was not vertical.

Dr. Voas: It appears the red and gold you described at sunset does not occur at dawn.

Cooper: Sunset is more of a golden orange.

Dr. Voas: Did you notice any of the flattening as the sun rose?

Cooper: Not as much, but you do get a little bit.

Roach: Going back to the time just preceding retro, were you constantly on stellar observation before the dawn? Were you able to follow any stars?

Cooper: Yes. With the sun to my back, the first thing I got was the moon glow and through the cloud below I got Shanghai. The first indication you get of the sun going up behind you is the lightening of the clouds underneath and you note the clouds getting lighter and lighter and you can still see the stars. As you reach a certain point, your window gets enough light - your window appears completely frosted over.

Roach: What star were you using?

Cooper: I was using Betelgeuse and tracking on up from that to Sirius and Procyon and then I had a barren area. Then I believe Castor and Pollux and Corvus was the last. I couldn't pick up Antares. By this time I was getting good light on clouds. The stars don't give you much yaw determination. You can sit there for a long time and if you hold rates very close to zero you can get a fairly good indication, but it is a lengthy process when you are determining yaw by seeing the movement of stars.

Roach: From that standpoint, is it better to retro in the daylight?

Cooper: You could probably do it at night, but it is preferable to do it in the day.

Note: The next few comments are not interpretable, but it appears someone raised a question about the blue horizon band visible during daylight.

Cooper: This is predominantly blue and if you have land masses or things that you know are not blue - - - but this is about a two degrees thick band. It isn't quite as thick as the band underneath - - - the last layer at night is thicker than this blue band and it is a brilliant blue.

Roach: Then, is there some structure above the blue layer?

Cooper: I never could see pattern structure above that. It is really not black. This is any time you have earth shine. This is not a real sharply defined - - - There is a little blue gray going thru this area here. The overall band is real bright pale bluw and just faintly diffuse on this side. (Explanation is made using a sketch at the blackboard.)

Question: Is it diffuse on the upper side?

Cooper: It is not just a real sharp line or two different distinct colors. It does diffuse very slightly.

Question: How wide is that band in angle?

Cooper: It is about two degrees.

Huch: I understand it gave a little problem in roll and yaw. You said just as the sun was sinking.

Cooper: That's right. This is where I could tell where the sun had been. I moved back to that and put the gyros to free and went into the automatic mode. (Again using sketch.)

Huch: With reference to the sunset, do you estimate the time when the Zodiacal light sequence was started?

Cooper: I would guess it was on the order of 20 to 30 seconds after sunset, that is just a guess. And this is all the counting I was doing to give you the timing and there was interference from the ground stations.

Huch: Did you observe capsule stability - did you feel it was holding sufficiently still for time exposures?

Cooper: Of course, we knew it would be moving. Did better than I thought it would.

Huch: For the most part they came out quite clear.

Bill Armstrong: You get pitch up at the rate of 4° per minute.

Cooper: Actually, you had more than that.

Shepard: During the Zodiacal light sequence, you had over 5 degrees per minute.

Question: What are your attitude tolerances in ASCS?

Cooper: I would say within about 5 1/2 degrees. This will be a very slow variance.

Question: How fast is this per minute? The period is 2 to 3 minutes per oscillation.

John Van Bockel: It is about .05 degrees per second.

Shepard: The limits could be as much as 11 degrees.

John Van Bockel: It is pretty close to plus or minus 10 degrees.

Cooper: Did you get anything from the latter portion of the picture? The airglow pictures?

Mercer: Yes.

Cooper: I worried that the angle of the camera was down too much.

Huch: Was there anything unusual that happened through the night?

Cooper: There was a lot of lightning.

Huch: Was there an accumulation of moisture on the window?

Cooper: No. To me it didn't seem to cut down too much.

Huch: You reported a lot of lightning.

Cooper: Right when I was taking dim light pictures there were several thunderstorms and a lot of lightning.

Shepard: Did you get any readout on attitudes?

Mercer: We got good attitudes.

Huch: On the pictures, can you relate the airglow band to what you drew on the board? Did you take any exposures into the sunlit sky?

Cooper: No, I didn't. I was going to try and snap one of this planet but couldn't get the camera out in time. After I once got it out of the equipment locker, the planet was gone.

Huch: Was the camera easy to use?

Cooper: Yes, after I once got it out of the locker it was easy to use.

Huch: Would it be possible to take a picture of the Milky Way?

Cooper: Yes. The last picture that I made was this haze layer when it was so bright. It should be somewhere right near. It was near the vertical coming through the window.

Huch: The range of light intensity was very extreme.

Cooper: The last exposure I made was of this glow and I think I used a 20 or a 15 second exposure time.

Note: A general discussion was carried on at this point concerning the number of exposures and general observations. It is not possible to decipher these comments into usable form.

(Radiation Experiments.)

Warren: We have some preliminary results I will give to you later. Did you take the chamber out of the ditty bag and fasten it on the hatch?

Cooper: I took it out of the storage container and fastened it to the hatch on the first orbit.

Warren: Could you give me a time estimate?

Cooper: I would say within an hour after liftoff.

Warren: Did you take it off prior to retro?

Cooper: Yes. I took it off just prior to retro. I stowed it in the glove compartment.

Warren: Did you take a reading of it at any time?

Cooper: No, I didn't.

Warren: Did you place it vertically? Where did you place it?

Cooper: I placed it vertically.

Warren. We got from that and also from film badger you carried on under clothing - - - We got an estimate of 15-20 milliroentgens. I think you would get more in an X-ray than you had here. It was about what expected.

Warren: Is there any particular reason that the 7th and 9th orbits were left out or were you just too busy?

Cooper: I don't remember which orbit I missed. I believe one of them I was quite busy trying to get this condensate water situation straightened out and debated turning it on later, but decided I had better not.

Warren: It wouldn't have served much use later.

Cooper: That was the 5th orbit.

Warren: The 6th and 7th were the ones missed.

Cooper: The 6th one was where I was having the condensate difficulty. I don't know why I missed the other one on the 9th orbit. We weren't schedule to run one on the 9th!

Bill: He had one at 9 hours and 40 minutes on the 7th orbit; then he had another one on the 8th, 11:15 to 11:25. And then you go into rest period after that.

Warren: We got that.

Bill: He went into rest period after that.

Warren: Late in the night, you turned the tape on continuous and it stayed on the rest of the flight. Was there any particular reason you could not have left the switch on?

Cooper: You mean the radiation? We hadn't planned to do this because of power

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conservation. It does take a certain amount of power.

McKann: That decision was made not to turn that on continuous because it had never been checked out for continuous operation because of some difficulties that might arise because of this.

Shepard: That seems to be a reasonable decision.

Warren: That is all I had.

Cooper: Did you get anything at all?

Warren: Particularly on the 7th orbit we got some date, that gave us quite a good bit of background. Thank you.

(General Observations)

Dr. O'Keefe: I understand the hissing noise was completely negative. Can you be sure it was not then?

Cooper: I didn't ever hear it at all. I had good fitting ear caps.

Dr. O'Keefe: Were you listening for it at the time?

Cooper: Yes, except I had my visor closed and with the visor closed you can't hear too much.

Dr. O'Keefe: At one point a rumor circulated in the public mess that you had seen a meteor.

Cooper: This was a false rumor.

Dr. O'Keefe: At one point you said you saw frost on the window.

Cooper: This is the material that turned out to be oil.

Paul Lowman: Have you seen the terrain photos? Have you seen number 8, east coast of Africa? Does it look this blue?

Cooper: Not quite. The film has fairly true reproduction but in several cases it might be a little more blue in film, than it actually is.

Paul Lowman: How about the shots over Himalayas?

Cooper: They look fairly true to color.

Paul Lowman: Where you're going over the ocean, could you distinguish different shades of blue?

Cooper: Yes, over GBI, Eleuthera and Cuba and right down the whole island chain, you could very definitely tell the shallower water areas. You could see reefs and green water in some of the lagoons. Not real distinctive green as you might think, and you could see sand at about its normal color. If you are looking straight down on things the color is more true than if you're looking at an angle. If you're looking at an angle, there is more of a bluish tint.

Paul Lowman: When you were over the deep ocean could you see any evidence of currents, at the coast of Africa or the coast of South America. Did you see different colors?

Cooper: There was some slight difference in color. I couldn't determine a pattern and couldn't determine what it was. I thought it might be wave patterns.

Paul Lowman: Were there different colors going over forest areas, over Africa? Were there different shades of green?

Cooper: Not too many. They looked to be a blue-green instead of a pure green. Greens didn't come through too well. They were somewhat diffused with this blue color.

Paul Lowman: Over the Himalayas, shot number 12, was the green true?

Cooper: Yes, fairly true.

Shepard: I think we should get weather records and corrilate the color with the moisture content.

Cooper: Did you get the list where I identified the pictures?

Paul Lowman: Comparing with these rocket photographs over in El Paso area, do you recall looking there or to west over Arizona?

Cooper: I didn't. I noted I was over this area. It looked familar. I had the feeling in looking out I was right over the Mexican Border. I don't recall just what gave me this feeling.

Soules: There is quite a bit of detail in IR photos.

Cooper: Just before that I noted the town of El Centro and the air base. I noted one little dry lake area east of there. I kept trying to see Muroc Dry Lake and Rosemond up north but never did see those, but saq several dry lakes. I saw one very clear. It was not a large one. It was about due east of Salton Sea area.

Paul Lowman: Could you see Biggs Air Force Base.

Cooper: I didn't notice Biggs at all, in fact, I couldn't see the main part of

the city of El Pase. I could see some little isolated civilized areas. I never did see the main part of city.

Paul Lowman: Did you see any distinct shadows from the terrain? Mountains?

Cooper: Yes. You could see shadows of the mountains quite clearly. Even more clearly than the mountains in the twilight were the shadows from clouds on ground.

Paul Lowman: How did the camera operate while taking pictures? Do you recall shaking the camera at any time?

Cooper: No: I don't recall shaking the camera at all.

Paul Lowman: They all look pretty good; I just wanted to make sure. Is there any vibration in the capsule when you are taking pictures?

Cooper: No. Very little. It is pretty smooth.

Paul Lowman: Do you think if you had a chance to sit down with those photographs, you could give us an idea of the inclination to the vertical or horizontal? You said over the West you couldn't see Los Angeles or San Diego, do you remember how far north you could see? along the coast?

Cooper: I could see three or four hundred miles on up north. There was a lot of cloud cover-a lot of stratus. You could see patterns where the ground caused difference in cloud formation.

Paul Lowman: How about on the east coast? Could you identify anything there?

Cooper: I could see the Cape clearly on one pass and the St. Johns river and could see where it came in the inlet at Jacksonville. Right to about Savannah, Georgia and clouds became broken and I could see banks of clouds lined on up to what I believe was the bulge of the Hatteras area and prehaps 150 miles on further. But clouds were obscuring. I felt I could see quite clearly on up north to Hatteras and perhaps on up to the Washington area. My sight of this was when I made my turnaround. It looked just like a map. It was a great wide expanse of

the East coast. But there was a quite a bit of clouds up north, broken clouds.

Paul Lowman: Were there any unusual terrain features?

Cooper: - - - - - -

Dr. O'Keefe: Did you see anything that looked like a crater?

Cooper: No. I sure didn't. I was looking for it too.

Paul Lowman: You went over one in Ghana, but I don't know if it was good or not.

Cooper: Over Africa there was unusual rocky terrain up in the Atlas mountains. I didn't see any craters.

Dr. Voas: Do you--could you see clouds and shore lines at night with no moon?

Cooper: Fairly well. If there was no moon you could see them faintly.

Dr. Voas: Any other terrain features that you could see? At night with no moon?

Cooper: No. Not much. You could see the moonlight on the water.

Dr. O'Keefe: You mentioned these small particles. Do I understand correctly that they seemed to be pushed outward from the capsule?

Cooper: If you consider this west and this east and the spacecraft is going east, regardless of spacecraft attitude, if any time I fired one of the thrusters at night, I could see glow from almost every one of the thrusters. The pitch-down thruster I could see and the yaw I could see shortly after they got out of the nozzle. You get tremendous streams of luminous particles of fireflies, and regardless of what attitude you were in, ther appeared to come out from the spacecraft. A great many could be seen for some period and they seemed to go back along flight path.

Dr. Voas: Did they actually appear to flow around? Would you say now that they were parallel. As they go back, they will appear optically to come together. But did they actually curve around as if there was a flow field.

Cooper: I felt they were actually moving around. Their relative movement was

not real fast. I could see them move right on out. In a matter of 4 or 5 seconds they would be as far away as the other end of the room. (50 feet). Some you could see for maybe as long as 30 or 40 seconds.

Question: Do you mean back from you or back along the flight path?

Cooper: I mean back the actual flight path.

Dr. Voas: Were these paths actually curved? You're of course familiar with the fact that as things go backward they appear to converge. Did they actually seem to curve in?

Cooper: If I would be sitting facing this way, the ones out of the left yaw thruster would move right out and move directly back along the flight path; the ones out of the right one would go out in front of me and would turn back.

John Boynton: Did you note any difficulty in identifying lunar features?

Cooper: I couldn't distinguish anything on the moon. It seemed considerably brighter. And seemed to have more light. I couldn't really distinguish anything.

Roach: Would it be practicle to have binoculars aboard?

Cooper: I think it would. The moon was much clearer than on the ground.

Huch: Could you see the earth shine on the moon?

Cooper: The moon was fuller when it was setting than at other times during the night. I never realized that before just now. But it seemed to be almost full when it was setting. But on the night side there was only a third of the moon. How about that now. The moon was almost fully round when it was setting. I think the pictures will show it.

Roach: That could be earth shine.

Cooper: That's right. It is a pale color, of course, in daylight.

Dr. Voas: Did it appear to you normal in brightness on the day side?

Cooper: Yes, it was just a lightish blue color.

Question: Could you determine wind direction and velocity by smoke?

Cooper: I could tell direction - over the Tibet area the wind was from the south.

Question: Did you see industrial smoke?

Cooper: I remember one fairly large area there was considerable haze and factory type smoke winding up, but don't remember where it was. It seemed to be like an inversion.

Hanel: You did not see the motion of the clouds?

Cooper: No I could not determine the motion of the clouds. Oh, you mean velocity by the way the smoke was moving.

Hanel: I mean the clouds were moving.

Shepard: Your first question was could he tellwind velocity and direction from the smoke?

Cooper: I don't know whether I could judge velocity or not. I could tell the wind was blowing fairly strongly, because the smoke appeared to come out of the smoke stacks flatly, it didn't drift up. But looking at the clouds, I could not tell which direction the wind was blowing.

Hanel: Did you have difficulty in seeing Cirrus clouds?

Hanel: Another question. We may have some trouble distinguishing snow from clouds in polar regions. You had no difficulty in distinguishing snow from clouds?

Cooper: No. I thought the snow was very very distinct. It is just like flying an airplane. Sometimes when the snow is very smooth and even, it is difficult to tellclouds from snow. You can determine the cloud height if you have a good perspective of the cloud height. You can tell whether the clouds are low or medium clouds or very high clouds.

Hanel: You never took two pictures of the same area? That is, two overlapping pictures?

Cooper: Yes, I think I did over the Himalayas. I have two pictures of almost the same area of the Tibetan High Lake area.

O'Keefe: Yes, they do overlap. They are pretty badly tilted, but they do overlap.

Hanel: Did you have difficulty in seeing Cirrus clouds? Could you estimate how much of the surface was covered with Cirrus?

Cooper: Surprising little of surface was covered with Cirrus clouds. I would guess about half. There were some areas where clouds were fairly extensive. Cirrus were biggest portion, about 75% of all clouds were Cirrus.

Question: Did you see any dust storms?

Cooper: At no time did I note a dust storm. I looked for them over Africa. One place I thought I might find them was over Arabia, but I saw no dust at all.

John Boynton: You mentioned that particles of dust or water were attracted to the window. Was this rapid or gradual?

Cooper: Very gradual. Numberous little dust particles, a little water and little crumbs. The larger objects didn't seem to be attracted. They just moved slowly about. There was less motion after we powered down cabin fan. Various pieces of dust or crumbs off of sandwiches I had eaten.

John Boynton: Did you note they might have been attracted to other areas?

Cooper: I didn't note any particular pattern. I did note the sun was very very hot through the window. The particular pattern of the sun would be hot on my suit. I would feel heat through my glove when I touched the window.

Dr. Voas: You seemed to have the general impression that you were stationary and everything else is moving.

Cooper: That's right. You sort of become the center of everything, and you think how you can move the earth around, when you want it, rather than move yourself.

Dr. Voas: Now, as you sat there with this moving picture in front of you, did you have the general feeling you were sitting upright or flying on your back?

Cooper: I did very distinctly feel I was sitting upright. A couple of times on account of the way you feel in the straps like hanging upside down. Every time I dropped something, I grabbed at it below. I never had trouble handling pencil. I never had any trouble putting it where I wanted or getting it. One time I made a wild grab for the camera as I thought it was going to fall, but of course it didn't.

Dr. Voas: On periods after you awakened, did you have feeling you had gone to sleep sitting upright?

Cooper: Yes. Definitely.

Dr. Voas: You mentioned sometimes you had the feeling of being upside down. Was this correlated with the spacecraft being inverted? Visually, I mean.

Cooper: No. I think this was purely a feeling of the straps. You're floating in the straps rather than being firm; like inverted flight in an aircraft.

Voas: Did you have a general feeling of being stationary? This general feeling of being stationary was not changed by any control action?

Cooper: I tried to give them some pretty good rates, but had no feel for rates at all.

Cooper: Vision-wise, you would see things changing ou then pretty fast, but it wasn't bothersome at all.

Dr. Voas: When you say "pretty good rates," this is 2 to 3 degrees per second?

Cooper: Three, four or five degrees.

Dr. Voas: At retro fire, did you note feelings of lateral motion?

Cooper: On the third one, it gave me pretty good little boot in yaw.

Dr. Voas: This is distinguished from what you could see looking out? As I understand it, you felt the retro rockets but they didn't change your impression that you were sitting stationary?

Cooper: All I did was feel them and I still had the feeling I was moving right along.

Dr. Voas: Did you feel you were moving backwards?

Cooper: I was moving backwards in retro attitude, then you get quite a motion as I stated over the earth.

Question: Did you have any sensations of change in attitude between perigee and apogee, perhaps as a result of the amount of curvature you could see in the earth's surface?

Cooper: No, I couldn't see any noticeable change in that. What was more distinct was whether you had haze or were in a clear area.

Lou Fisher: We identified one of your pictures taken vertical off Calcutta.

Cooper: Did you note the one before that over the Rangoon area, with the little things out over the river; they look like warehouses or something?

Fisher: Did you see Calcutta?

Cooper: No.

Fisher: Did you see any airports?

Cooper: Yes, I saw numerous airports. The runway patterns show up very distinctly.

Boynton: Did you find that later in the flight audio inputs became more startling or more distinct? Did they seem to be more profound?

Cooper: Later in flight, I began to notice the relay panel wiping back and forth whereas I hadn't noticed it before. The music sounded pretty good. If I'd had a radio on board, I could have used it.

John Boynton: Did you find you might look forward to hearing communications, say more so than in the first of the flight?

Cooper: No. Not that I noted.

John B.: Could you hear better?

Cooper: No.

Dr. Voas: Did you at any time hear an unusual noise?

Cooper: No.

Roach: Was there any change of radio static in electrical storms? In connection with the problem of radio static, there is a phenomenon of static going to and fro between the hemispheres, when it returns it comes back as a whistle. Did you ever hear a whistle?

Cooper: No, I didn't.

Note: Some questions were then raised concerning the appearance of the horizon at sunrise and sunset. Cooper stated that the horizon near the sun was a golden color at sunset, spreading away from the sun. He stated: "The real dominant thing is that it is gold as it is setting and it is real blue as it starts to come up." He stated again that he saw the Zodiacal light both night and morning. It was a very low order magnitude light, about the same at sunrise and at sunset. He estimated its elongation to be about 15 degrees.

SCIENTIFIC DEBRIEFING OF LT. CMDR.

WALTER SCHIRRA

HELD AT NASA HEADQUARTERS, TUESDAY

MARCH 12, 1963

FOR OFFICIAL USE ONLY

15 November 1963
In Reply Refer to:
SM(JRG:nem)

MEMORANDUM FOR: All Participants

FROM: J. R. Gill

SUBJECT: Scientific Debriefing of Lt. Cmdr. Walter Schirra, held at NASA Headquarters, March 12, 1963

This document is a literal transcription of the subject de-briefing made from the tape recording. It is issued to participants only for their comments and/or recommended deletion. Deadline for receipt of this is December 20, 1963. After that time an edited version may be prepared for wider distribution.

Jocelyn R. Gill
Jocelyn R. Gill

Enclosure

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Dr. Eugene M. Shoemaker, Chairman, Manned Space Science Working Group served as Chairman, substituting for Dr. John Clark, Chief Scientist. The following people were present:

Mr. Carl Abraham, NASA Headquarters
Mr. Richard Daniels, NASA Headquarters
Dr. Winifred Cameron, Goddard Space Flight Center
Mr. Maurice Dubin, NASA Headquarters
Mr. Larry Dunkelman, Goddard Space Flight Center
Dr. Jocelyn R. Gill, NASA Headquarters
Dr. Dale Jenkins, NASA Headquarters
Dr. Urner Liddel, NASA Headquarters
Mr. Oran Nicks, NASA Headquarters
Dr. John Nordberg, Goddard Space Flight Center
Dr. John O'Keefe, Goddard Space Flight Center
Cmdr. Walter Schirra, Manned Spacecraft Center
Mr. George Tennyson, Goddard Space Flight Center
Dr. Eugene M. Shoemaker, NASA Headquarters

Dr. Shoemaker - I have a series of written questions to start things off. These have been submitted by some of the people here today and we may then ask for some supplementary questions from the rest of the people this morning. We might start off with the question on airglow. Will you give us an account of Mercury's passage through the airglow layers? How did you identify the planet Mercury? Did it seem to have color? Were there any stars nearby?

Cmdr. Schirra - I think Larry Dunkelman and I discussed this at

great length and I don't know whether we could be any more expansive on that subject than we have already. The only thing that I can think of that we didn't talk about is an effective color of the planet Mercury. It was as white to me as any other star. It was not blue, red or some other color. It was definitely "star-appearing" to me. It would have a definite atmosphere where it would change colors and where it didn't have any atmosphere, it didn't change colors. I would say that from that it had no different appearance than if I could see it from the earth as a star. Mercury itself was plotted on my star chart, which is a very valuable tool for these flights. There is just no doubt where Mercury has to be and we checked on it and, of course, it was Mercury. I think Larry called me one day and we all were surprised that I saw Mercury longer than I should have seen it and I guess this was explained by its being seen through the refraction of the atmosphere. Is this correct?

Dr. O'Keefe - Yes, that's the answer. Mrs. Cameron is the one who made the contribution. This is her theory.

Schirra - This was a tremendous yardstick as far as I was concerned. It was so obvious to me that I just had to take the time to describe its passage through the various layers of light and the way I described it in the handouts "Results of Third U. S. Manned Orbital Space Flight, October 3, 1962" that you have is about as accurate as I can describe it now.

Dr. Gill - Could you make a little drawing on the blackboard for us?

Schirra - Again, Larry, do you have that? (Referring to drawing prepared by W. Cameron and L. Dunkelman)

Mr. Dunkelman - We have.

Schirra - We sat down for about an hour and traced this very carefully.

Mr. Dunkelman - It happens that the movement of Mercury behind our atmosphere is really not phenomenally related to airglow as such. Mercury is simply a pointer - an index finger. It gave us a chance to see what parts of the upper atmosphere you were looking at and this has more to do with ozone and atmospheric constituents than it has to do with airglow. We think the answer here lies in the fact that the ozone is absorbing the orange, yellow, and green light and leaves this interesting blue which is an ozone blue rather than a Rayleigh blue and we think the reason why Astronaut Schirra saw the several shades of blue is he may have been looking edge-on at the ozone layer. So it is really not so much related to airglow as it is to the way of looking at what produces the color. I think we are interested in finding out what causes the phenomenon, rather than to attempting to learn anything new about the atmosphere.

Schirra - I think one of the reasons that I was so enthused about tracking Mercury through these colors is that I am a fan of blue colors. I grew up with a Maxfield Parish painting; if anybody knows his colors of blues - they are fantastic. Gold blues, electric blues. As a result, these caught my attention. I am

not that much of an artist or poet, but I was trapped with this set of blues and I did expand on it at greath length, I thought. These electric blues -

O'Keefe - (Interrupting) Subtraction is what it sounds like.

Schirra - So it connotes ozone in that sense - electric blue - is exactly what it looked like. A very, very satisfying color.

Dr. Roman - Coming back to the color of Mercury, do I gather from your comment that you feel it was distinctly yellow, yellowish for example, or was it that you didn't pay a great deal of attention to?

Schirra - No, Nancy, I would say it is very much like any other star that I would see, rather than having a color. I didn't detect a color.

Dr. Roman - Astronomers think of stars as having color.

Schirra - I have seen different-colored stars from earth-bound environment and anticipated or, in fact,I was looking for different colored stars or planets and did not detect any colors.

Roman - This means that your background was just a little too bright to see colors.

Schirra - That, and the window itself just isn't an optimum plate - series of plates - to look through. I insisted that what I really felt had happened is that I was seeing no more than about 5th or 6th magnitude stars that the clouding of the windows, as a result of the escaped rocket, reduced my visibility of the stars about one magnitude. In other words there wasn't gross clouding of the window. That is what I was trying to make clear by using magnitude of stars as the yardstick in this case. I'll stick with that. This

is about the best way I can describe it. I could see more stars, as Scott Carpenter described it, when back on the surface of the earth and many, many more stars in an airplane cockpit than in orbital flight.

Roman - You could see more in an airplane?

Schirra - Yes. So in the debriefing of the flight I stated that this is not a problem for pursuit of Mercury flights. It is a problem for pursuit of space observation and with the Gemini vehicle, we have solved this by having the windows properly covered and also we hope so - well, Gemini doesn't have an escape rocket for one, which helps us. Now on Apollo, we are plus or minus on whether we can afford the weight of having window covers, but if we do, it does have an escape rocket. If we have covers, then these windows should be protected. And better, because we will need the stars on this particular mission. But to go back and try to cover the Mercury window at this late date would be prohibitive hardware-wise and schedule-wise.

O'Keefe - What would you cover it with?

Schirra - First of all - for Gemini, we have no problem. There is no tower rocket. With Apollo they had window shutters the last time I saw the mock-up which is not at all static. It is quite dynamic even though it hasn't flown. How this will be done I don't know, but I think this is a requirement. I don't even think it; I know it is a requirement for Apollo.

O'Keefe - You don't think there is a possibility of putting a thin - say, some transparent grease over the window - which would come

off in the vacuum?

Schirra - This might be a way of doing it. Having it sublime away or something of this order.

O'Keefe - That could be done. If that were done ...

Schirra - I definitely feel that this should not be a neglected problem; if we, for example, do remove the window cover from the Apollo command module. It definitely should have some type of protection when the star rocket goes. This is going to be a by-product of its own combustion, it won't leave marks on the window. I saw marks on mine as well as a clouded effect and I feel so strongly about this -- When I had the sun at oblique angles shallow to the window I could see this film much as you describe it. Smokers in the group will appreciate this. On the inside of an automobile window, you can see the smoke condensation on there which you very rarely get washed off until you wash the car yourself. You see this when you have light at very oblique angles across this window. This is about the same type of intensity - it is not enough to restrict your vision although it does affect it at night. This is exactly why I make the point. I think that is about the easiest analogy I can make for you.

Dr. Nordberg - You say this was on the Mercury window after the exhaust.

Schirra - Yes sir, this is the result of this exhaust gas bathing this window as the rocket lit and left almost instantaneously, but the gas does form over it.

Nordberg - Could you, were you able to observe, during the orbital flight any decrease in the film on the window. It may have evaporated away, or did it just stay?

Schirra - I was hoping to see that and I did not observe a decrease. This surprised me too. I would anticipate that that gas would sublime away. I suspect that the vehicle itself - we are getting into the fireflies again - but the vehicle itself is surrounded by an environment. We have the same problem when we try to run a capsule or spacecraft in an altitude chamber. It is outgassing the water cooler systems and other components even in a man-created vacuum and as a result we can't maintain this vacuum because it is creating an environment all the time. I think this is what we have done in the Mercury spacecraft with the by-product hydrogen peroxide gas and the water coolers and this is where I feel our firefly, frost particles come from. Did you notice by the way- getting into that, - that the particles were observed almost immediately after I was in orbit? - I said, "I see frost flakes."

Mr. Dubin - You were in sunlight at that time too. ...

Schirra - That's correct. This is my only definition of the difference in the way the sunlight itself gets to where I was. Meaning that at sunrise it goes through a lot of atmosphere, and as I get into sun above my horizon, I have no atmosphere; so then its white again.

Nordberg - This deposit is of great interest to us. That is

why I asked the question because we observed this on Tiros too. One of the two cameras was just completely clouded for a few hundred orbits and then gradually after a few hundred orbits it improved a little bit.

Schirra - I need a little more flight time! I'm all for it.

Nordberg - We eliminated this by putting a sheet over it in third stage and since then we have never had any trouble.

Schirra - Sure, that's it. I am sure this is something we can't let rest. We've got to cover these windows to protect them from clouding during the transition to where we are now to space itself.

Dubin - Do you ever detect any gas around the vehicle? In sunlight due to shadowing of the vehicle.

Schirra - No, I looked for that. The only vestige of something around me were these particles as we have described them.

O'Keefe - Well, it is very helpful to know that they were seen throughout the day.

Schirra - Yes, I think really what it depended on was how much sunlight I had coming through the window. If it was really bright within the vehicle, I didn't see them as well. If I got an off-angle where the sun was fairly shallow in relation to my window, I could then see these particles; of course, up until my local noon, I did not see them anyway.

O'Keefe - About this problem of condensation and the local environment you are speaking of, I think that someone investigated that at the Manned Spacecraft Center. It is quite true that with an outflow

of gas like that the ambient pressure - the general ambient pressure - is quite different from the pressure right around your vehicle. I still wonder whether you can get the pressure up around the vehicle for the level where condensation takes place. I have been trying to persuade some people that the condensation takes place before it leaves these ports of course as it spreads out in space. The pressure is certainly much higher around the bottom of the heat shield, but I do not know whether that is right or not.

Shoemaker - Do we have any more questions on the airglow? They are very useful.

Dr. Liddel - We have two problems here. One is the pressure and the other is the rate of evaporation.

O'Keefe - That's true. Once formed, they may not sublime out. Question is how were they formed.

Schirra - I think there is one thing that we might bring into this before we leave it unless there is a separate question on it. The green-yellow, almost a chartreuse, coloring of these particles, I feel, did not permit you to see the edges of the particles as well as they appeared when they were in the white band in the sense of looking like frost particles. So they looked more like blobs and this is typical of fireflies themselves. You can't define the size of the blob you see as green-yellow, but if you see a snowflake, which is white, you can very easily see its edges in a sense. Not that you focus on them but you can visualize that they have edges. This is a point that I don't think I have made in the past,

but I think this is basically why we refer to the white particles as frost because it does remind us of this. This is what probably tempts me to say that it has to be water.

Cameron - Do you think the chartreuse ones were maybe the ones that Glenn thought actually glowed, didn't he? They were lighted wrong.

Schirra - I think - well this gets back to my opinion and I saw myself on film yesterday at the press conference talking about it and said that I guess we need some more opinions but we have three opinions now and basically I put two together and made my own, but the green I feel is strictly the case of the sunlight going through this tremendous amount of atmosphere at sunrise. What is left as a light spectrum is this green-yellow on these particles. You can all explain this better than I can, I am sure, but what gets through all this atmosphere would probably be this green-yellow. I think that in a sense they are not self-illuminated but they reflect as if they were self-illuminated.

O'Keefe - Well, if you pass sunlight through a thick layer of atmosphere then, of course, what you will get will be a red - a deep red - however, that doesn't necessarily prove that you are wrong in what you are saying because the things would be illuminated in two ways. They would be illuminated not only by the direct sunlight, but also by the scattered light around the horizon which you have photographed at sunrise and the combination of these two colors might give you a chartreuse as you have said because it is a double illumination. However, there is another possible

explanation. If it is really true that this chartreuse color only turns up only at sunrise, we may be with the explanation that Herzfeld[1] put forward for it.

Schirra - This is the nitrogen effect?

O'Keefe - Yes.

Schirra - I would like to stamp that one out. We can't afford to have nitrogen outgas in the vehicle. (Laughter) The only nitrogen which we have stored aboard is that which pressurizes the hydrogen peroxide system. If we lose any of that, this is almost fatal.

O'Keefe - Well, there is plenty of nitrogen in the atmosphere at that level. Still -

Schirra - You mean in the external atmosphere?

O'Keefe - Yes. Ambient atmosphere.

Schirra - Fair enough. Well then, that paper - I was left with the impression that the nitrogen came from the vehicle itself.

O'Keefe - I am sure that it didn't cross Herzfeld's mind.

Dubin - There's also nitrogen . . .

Schirra - Well, it read that way to me. I should say that I am very conscious of what nitrogen does for me within the vehicle! (Laughter) This is basically my control field.

Dubin - I was going to say there is also nitrogen absorbed in metals...

Schirra - The gaseous content of the vehicle is very carefully measured prior to sealing up the vehicle for lift off. It is purged and we go up to about 97 or 98 percent oxygen. Obviously, there is not much left in the cabin, you can't get it all out because

1/ Abstract published in Vol. 136, #3522, p. 1121, July 29, 1962 of Science by Charles Herzfeld.

you just can't purge particles in the interior in that these are angles and trap volumes, but I would suspect that we had a very low order of nitrogen gas within the vehicle that could come out. Now it can come out if the vehicle's leak rate - in the vehicle is excessive - and in this one it was somewhat less than 600 cc. I think it was about 500 -

Dunkelman - 588.

Roman - I think your suggestion, Larry, was that it would be on the outside of the vehicle.

Schirra - That I hadn't had a feeling for and I suspect this is the only way you could get it in contrast to getting it from within. So I won't argue this point. I am well aware of the fact that it could be adsorbed and then passed off in this environment.

Roman - John, (to Dr. O'Keefe) is it obvious that sunlight coming through in the upper atmosphere would be red if you are above the dust layer?

O'Keefe - Well, when you look at the sun in the photographs which were taken, it looks red.

Roman - I see.

Schirra - The sunset is red. Same old sun that we see here.

O'Keefe - Yes, but what you'd see on either side of it - flanking it - is Maxfield Parish cloud, at least in the color photographs. I think this is what Maxfield Parish went in for particularly. He went in for very powerful colors - subtraction colors. Turquoise - rather than the pastels, rather than colors of the spectrum.

Shoemaker - Any other items on airglow we should take up?

Schirra - We will bring up this other thing I saw - I guess?

Shoemaker - The cloud (bright area) you saw over Madagascar?

Schirra - Yes.

Dubin - I was wondering on these various effects on the horizon. You make some statements about the blue horizon--the different colors.

Schirra - What time is this?

Dubin - This is at 06 44 GMT (See blue book, p. 104). (Now Report of Third U. S. Manned Orbital Flight.)

Schirra - This was the beginning to what Mrs. Cameron has a sketch of, I believe. ...

Cameron - Actually you give two descriptions here. I believe they conflict. I assume that one is an expansion of a part of the other.

Schirra - It is, and as you can see, it's a time span here where it obviously is changing as the sun is setting as well. Not much in time, but my time was pretty fast in relation to sunsets, I guess.

Dubin - Question is what the heck did you really see?

Schirra - Maybe if I just read it back myself, I can expand on it. I'll read it out loud. How's that? I guess we can pick up right at 0604 33 and I say there is a nice interesting horizon, which meant that I was captured by it. The sun was off to the left and I would say about 40 degrees. This just

meant that it was off to the left of my yaw angle - I was in flight path in yaw at this instant of time - which means you could determine where the vehicle was oriented and then also get the sun-line in relation to the window.

Cameron - Incidentally, the sun must have been very close to setting at that time, wasn't it?

Schirra - It was setting, in fact. This is where I went on. There is a dark line at the surface of the earth, orange at the clouds. Now there was a cloud horizon, as well, that I could see. Then a light yellow, a light white, and then a blue band. This was coming from the surface of the earth going up. A very light blue and then I got all excited and said that I had the planet Mercury in sight at this point. Mercury obviously was in the black. It had not come down into the Mercury set. If you want to describe it in the sense of sunset, Mercury set. I think it deserves the term of having the opportunity to set as well. I was coming up from the surface of the earth towards the darkness of space and then I detected Mercury where it belonged, trailing the sun.

Dubin - Well! The sun was off to your left about 40 degrees.

Schirra - As well as Mercury.

Dubin - In the same direction?

Schirra - It was trailing almost above the sun in this sense. Which is where I had it plotted on the star chart. Then I wanted to describe the blue band and I said that there is a

relatively dark blue band right at the surface of the earth. Of course, the orange and light yellow was changing at this point and I then came into seeing this dark blue band. In other words, I had lost the orange cloud effect just above the surface of the clouds. This was the same kind of red-orange we typically see through the atmosphere on the surface of the earth which is, of course, the atmosphere. I realize this cuts out most everything but reds and yellow-orange. But the light yellow wasn't at all unusual either; I had seen this in many sunsets. The sun had set. I wanted to describe this blue band. I realized I had gone through some 34 seconds. When I say describing the blue band, it is some 30 seconds later. Took me, say, 4 seconds to say that. Relatively dark blue band right at the surface of the earth and a light blue band meaning a next band above it; another dark blue band, a large white band which is the airglow. This is the way I felt it should be. I have not made a careful study prior to the time of the various layers on the earth or above the earth. Then a deep black one and it sort of goes from a grayish blue to a dense black, almost looks like the underneath surface of a summer cumulo-nimbus effect, where you have a nice bright earth and then you go into this black cloud and then there is this roll cloud that precedes a thunder storm and it's a very, very choppy underneath surface. It looks very turbulent, to you. This surprised me. I expected to see another sharp line and I did not. This is what

I was referring to here as the transition from the last blue band I could see to the total darkness of space. I guess this is the only way I can describe that. This was a surprise to me to see this, really.

O'Keefe - Well, it is astonishing, isn't it?

Schirra - Yes, it is. I expected to see a nice, sharply delineated arc, and this was not the case by any means.

O'Keefe - Whatever it was, it was turbulence?

Schirra - Yes, this is the way I would describe it. It has to be or the light in a sense made it look turbulent. I think you have all seen the base of a thunderstorm as it comes towards you and the light starts diminishing rapidly as you get a thunderstorm. Just because it is so thick and almost opaque in contrast to sunlight that can get through. Then we see this vortex effect underneath it and this is very much the way I would describe it myself. This was the transition from visible to no light. No sharp line. I think you probably have it fairly well sketched right there.

Dubin - Have you seen the sketches? (Mrs. Cameron's sketches of colored bands around the horizon.)

Schirra - No, I haven't.

O'Keefe - Why don't you take them around there, Mrs. Cameron ... so we can get additions and corrections (to the drawings).

(Schirra and Cameron looking at the drawings)

Cameron - This is your first description (drawing shown to Schirra) ... This is the second description. ...

Schirra - Yes. Now as we progressed in time to the second drawing, the sun has now really set and the reds and yellows (in the drawing) are fine ... now just getting the afterlight ...that's the ragged effect I saw. ...

Schirra - This isn't as thick as that grey to black band as I saw it. We are stuck with a small circle (radius of curvature used in the drawing) and I had a big circle.

Dubin - Okay, could you re-draw it on the board the way you saw it?

Schirra - All it is is a straight line with a slight curvature to it. I had a broad angle of view, but the whole thing is flattened out. I don't see that much curvature at all.

O'Keefe - (to Mrs. Cameron) Put in that remark about this band is too narrow?

Schirra - This is too wide. (indicating drawing) It would be the grey to black (band).

Shoemaker - It faded out more rapidly in proportion to the white band?

Schirra - It was definitely not something you would like to make with a compass.

Cameron - Narrower and wider ... I tried to indicate that, but as to scale, I didn't ... I was just trying ...

O'Keefe - We made a first try at it ...

Schirra - (Reading in the Blue Book) "I will bring up the fingertip light." This will clue you. This will make it

clear to you that the internal lighting was off inside the vehicle. I don't know why I didn't bring that point out. This reminds me that it was dark and it was 0605 52. I had to see what time it was. We had this counter clock as you know, and to see the numerals I had to bring my fingertip lights up to see them. It was quite dark within the vehicle and this is quite an advantage to this observation. Then I say that Mercury is on the horizon and this meant that it was just coming down through what I described going up, if you can follow my directions here. This is where Mercury was as the pointer or index as it passed through these layers. Now again, we proceeded through time so that light patterns will change and that's why these descriptions do conflict as we progress on in time. I think this might explain why. As I come back through with Mercury now setting these same light bands are not the identical ones that I described previously and I used the word "airglow" and even the way it came out in the tape I said see the Mercury going through the - and I was searching for a term and so I just said "airglow" just so I wouldn't have to get into a big discussion about what I was going to report on. Actually, I could have said through the -- I was searching for a term -- but this "airglow" I was using simply as a term to describe what I was looking at. I could have said through the lighted horizon.

O'Keefe - Twilight layer is probably a better way to say it.

Schirra - Very good, a better way of saying it.

O'Keefe - "Airglow" is a very complicated term. We don't know what it is all about. That's what we are after. ...

Schirra - In fact, on occasion I have used airglow through here just out of ignorance. I think what we all are trying to do right here is to try and clear up some of this ignorance; so we need more data, of course. Then,I say (reading from the Blue Book again) "We'll see if she holds up," meaning, can I track Mercury through all this? That was interesting in itself, that I could, I thought.

O'Keefe - This was quite important. This was one of the questions raised by Glenn on his flight whether some layers are opaque or not.

Schirra - I could track Mercury through all of these points or layers.

Nicks - Does it change its apparent size like the sun when it sets?

Schirra - I don't recall having observed this.

Roman - Did you see any additional stars ... the fact that it has a finite disk (Mercury)?

Schirra - No, again the window cuts out the fun of that, I think.

O'Keefe - No, you wouldn't see a disk. ...

Schirra - It would have been great to have had some magnifying device at this point to make this observation. No, it just looked

like a star.

O'Keefe - I think when Nicks asked if the sun changed in size, he really - the sun doesn't change in size as it sets. He meant change in brightness.

Schirra - Apparent size - not the size, but the illusion at least. I've got to break off a second here. I don't recall seeing many moon sets on earth. Have any of you ever seen a good moon set?

Roman - Yes.

Schirra - You have to be on the West Coast to do it; but, of course, I saw a moon set on this flight and that is why I brought it up. To me, it was the first real good moon set I had seen. (Laughter)

O'Keefe - There is a good solid reason for that. That is that a full moon will set at sunrise. Not many people are up at that time.

Schirra - I hope you have had a chance to see the photographs I took of this moon set.

Gill - No.

Schirra - There are two black and white sets of these. The original prints were very good. I understand there is a lot of halation around this. I definitely think you all should get these out and examine them. Now the subsequent prints were not very good. They were too fuzzy.

Gill - Who would have them?

Schirra - Paul Backer could trace them down at least. He was the film-handler. He could chase them down.

O'Keefe - Minnaert has suggested that after moonset, that there might be a lunar zodiacal light. (Minnaert, Light and Color in the Open Air, p. 295.)

Schirra - Oh.

O'Keefe - It's a dim hope.

Schirra - Getting back to this light magnitude in relation to stars is about 12 to 15 magnitude. I wouldn't even see this. I suspect Gordon won't unless he just happens to look out at the right time and has enough lighting. Now with instrumentation we could detect it, but visibly with the naked eye you can't detect because you can't see through the window. You can't detect this low illumination level. I might add that I saw something subsequent to the flight that really flipped me. I was on route to the West Coast on a night flight (commercial). I was sitting way in the back in the tourist section in middle of a three-seater, and thought I was anonymous, when the stewardess came roaring back and said "Cmdr. Schirra, would you come up front;" and out of my obscurity I was drawn to the cockpit and I said to myself that we've either lost a pilot or co-pilot. (Laughter) So I went roaring up front and the passengers were looking with a degree of apprehension, at least. I went up to the cockpit and looked out and we were heading West just after sunset and a

blue scout had been launched from Vandenberg (AFB). It had the most fantastic lighting I have ever seen anywhere. It had the exhaust trail and above the horizon it had this fantastic glow - ionization glow (like a vapor cloud) I would describe it as - which would best pin down -resemble- the zodiacal light if you ever wanted to do it. It had a band across the horizon about 60 to 70 degrees and it went right up the ecliptic and picked up the moon and the planets. It was just amazing.

Shoemaker - How far could you trace it?

Schirra - I could see it right up to the zenith as much as I could see out the cockpit. We were all oohing and ahing. I think you have seen this same glow from a booster flight at night, particularly if you can pick up a sunset or sunrise when you get above the earth's shadow and get into the lighted area where the booster is. There is a tremendous expansion wave that's behind the vehicle and this is basically what it looks like.

Dubin - These pictures of Glenn's Atlas flight show the same thing. ...

Schirra - I think it was mine you saw...

O'Keefe - What you saw from the cockpit - was it from the blue streak or was it the zodiacal light?

Schirra - I think the two just drew it together and that it was definitely stimulated by this blue streak as it went up almost up the ecliptic in relation to the arc field of view.

O'Keefe - It is not a difficult thing to see the zodiacal light under reasonably favorable conditions.

Schirra - No, I have seen it frequently, but not as brilliantly.

Gill - Have you seen it in Houston by any chance?

Schirra - I have seen it just flying at night. I haven't seen it from Houston recently, no.

Gill - Well, this is the season to see it. You should see it... about three-quarters of an hour after sunset.

Schirra - From an airplane, you can see it better than you can from a Mercury spacecraft. You don't have this dimming of light through your canopy as you do from the spacecraft. This is really a spectacular sight. Of course, the pilots were so concerned because they didn't know what it was. This was hundreds and hundreds of miles away, and yet they felt they were in danger. (Laughter) They wanted answers right away.

Gill - They got them, didn't they?

Schirra - Of course, you've heard that the whole West Coast was enthralled by this sight. It was in the newspapers.

Roman - Speaking of the brightness of the zodiacal light, Dr. Mulders, NSF, was in Chile at a high altitude last fall, and he commented to me, that the zodiacal light was so bright that he was able to see it from horizon to horizon without difficulty.

Schirra - Amazing--horizon to horizon--I am not sure what we are going to see at thousands of miles from earth. I suspect that

we are going to see a batch of clouds if it's lighted. (the earth) That's really what I saw a lot of. I was just amazed. Obviously, when I flew over Africa, it was loud and clear and you would see this if you were looking at Africa from some vantage point many, many miles away. I suspect that if you looked at earth from a long distance away that there is so much cloud cover that it might have an appearance much like Venus in this sense.

Shoemaker - While we are on Africa, would you like to go on and talk about the...(interruption)

Schirra - You can't match my blues. Maybe Parish could help ...

Nordberg - Does anyone have anything on the altitude, particularly on that top that sort of turbulent thing?

Schirra - That's another one you should check into. Through the trajectory tables, you should find my altitude. Now at this point, I was just passed Indian Ocean ship as I recall.

O'Keefe - We've done all that. If you say when Mercury went through that we will tell you what the height was. (To Cameron) You have it?

Cameron - I have it. It's about 280 kilometers. Height of the layers is about 66 kilometers. I only know the height of his observation, not knowing the width of it.

O'Keefe - (to Schirra) But you made a mark when you went through it. The first "time hack" was when you were going through this turbulent area, right?

Schirra - Correct, that's when I came into it.

O'Keefe - What was the height of the layers at this time - 66 kilometers, is that right?

Schirra - Right, that's what I was saying. I hope we can hold Mercury meaning that I'd like to see it go through this and I did not know that I could, but obviously I proved that I could; I did. This was quite a surprise. Didn't you say, Jocelyn, that there aren't many people that have seen Mercury sets?

Gill - Very true. Mercury, (the planet) period. Very few people know that it exists.

O'Keefe - Can I point out that you used the word airglow just in general terms, a faint, glowing light seen from the atmosphere without your - What you called the airglow is not what is technically know as the airglow.

Schirra - Yes, any time we use airglow I don't use it as we professionally talk about airglow. I was using it merely as an escape clause.

Dunkelman - There is one other point there. One isn't sure just in what plane these phenomena took place. They may have been ahead or behind this plane (of the spacecraft). We have to think of this... The 66 kilometers might indeed be reflected as something that had been before this point, you see.

Nordberg - (Comment inaudible).

Schirra - My local vertical would be this hand as I show it and, of course, 40 degrees to the left where the sun and

Mercury were traversing was in a plane something like this. This is your point I think, Larry, Isn't it?

Dunkelman - That's one ...

Schirra - So they come down this way which mathematically isn't hard to solve, but you should consider this.

Dubin - This plane may vary a certain amount and it is very difficult to know which way.

Schirra - The spacecraft at this point was under attitude control and was fairly tight in a sense.

Roman - I think Larry's point is that though we don't really know if we are ... if we are actually taking a traverse straight through the atmosphere, it may be something in front, a tangent line, or behind it.

Dunkelman - The first thought is to put a line right through there, and at this point this may be on the plane but it may not be that. Some may be ahead or behind, or both. ...

Schirra - In other words, these layers in this sense could be all staggered out and this one stacked like a bunch of steps in a sense.

Dubin - And they could be higher in altitude than a simple right angle projection.

O'Keefe - It's quite safe.

Schirra - I was looking at two dimensions in a sense.

Cameron - The right angles of projection and this is the twilight zone of the spectrum.

Schirra - If there is another one of those coffees, I'll trade this one in. I don't mind it cool.

Break (General conversation)

Schirra - And the rare occasions that I've had the timing for this.

O'Keefe - There is a nice Delta Flight from Washington down to Houston. The thing goes exactly toward the sun - you can't miss it.

Cameron - You'll have to go to the cockpit.

Schirra - Hmm - You have to make the Delta Flight, in this particular case, from Dallas to Los Angeles. I passed Albuquerque.

Shoemaker - This peculiar thing you saw over Africa - maybe you could tell us about it.

Schirra - That, as I have said, was my biggest surprise. I talked to most of you at great length about things we would hope to see or expect to see. This I had no prior knowledge of and I basically can say that I was "sucked" in and originally called this airglow, if you recall. I guess it is best to refer back to the record again. This was 5 hours and 20 minutes.

Cameron - That's the time I got from you. The only thing I notice from the script was that you said Glenn was asking you when you were passing over California if you had seen what the airglow was. Then you said something about you were surprised at how high it was.

Schirra - This was the same phenomena. I had come back from there, I think, isn't that correct? Let's see.

Dubin - The Indian Ocean.

O'Keefe - David Stern at Goddard predicted that you would see something very unusual in this flight before you went up. ...

Schirra - Really?

O'Keefe - Yes, he gave me a note. I was supposed to pass that note down to the Manned Spacecraft Center; I don't think I did. I think it's my fault. (Ed. copies were forwarded to MSC.)

Roman - What is this you are referring to?

O'Keefe - There is a very strong magnetic anomaly in this region, and this is where ...

Dunkelman - I think the fact that Schirra had not heard of this makes the observation even better scientifically.

Schirra - Hmm.

O'Keefe - Quite exciting about this thing, but exactly what region is Cdr. Schirra talking about? ...He's talking about the South Atlantic - and the South Atlantic was in sunlight. This is probably as close to it as we could get to be in darkness.

Schirra - I think what happened is I looked out as I was drifting and this happened to be in the right attitude to see this, which probably meant that I was looking toward the North although I can't confirm this.

Cameron - You said something about you would judge that the width was about a fourth of your window.

Schirra - Yes.

Cameron - Can you say how far - anything about how high it was from the horizon?

Schirra - I was surprised when I saw what I thought were city lights and they turned out to be stars below this thing. As a result, I was confused in the sense that I wasn't then looking for yardsticks.

Cameron - Was this a patch, or do you think there was a layer there?

Schirra - It was a layer across my whole visible horizon. It wasn't just a blob in other words.

Cameron - And is that the only time you saw it?

Schirra - That is the only time that I recall ever having seen it. At one particular point - Was it at 5 hours 20 minutes (in the record)? I don't seem to refer to it too well in here.

Dunkelman - We had to find it.

Schirra - You had to dig it out?

Dunkelman - We had to dig it out from your self-debriefing later.

Roman - Was there any color apparent in this case?

Schirra - I would like to refer to it, Nancy, as a little smog color, having a little brown in it. Sort of Brownish gray - rather it wasn't black or white. It was definitely toward the brown smog thing. I'm sure you have had the unfortunate privilege of letting down in Los Angeles and seeing what smog brown is.

Roman - Right.

Schirra - This isn't what you would see from the surface of Los Angeles, but above it when you look into this. Sort of a dusty color in a sense. If you'd like to use that term. I don't like to use that term because if you have seen a dust cloud you've seen more solidity to it in your mind at least. I don't want to give you that picture. Definitely a fog effect rather than seeing particles. I think of it that way.

Dunkelman - We are here to hear yours and I think we should figure out some more of this. I don't want to inject my thought into this, but I was trying to quote you in saying that it is brownish smog layers and wasn't sure how to define it.

Schirra - Yes. This is dirty brown, not a pleasant brown, not one you would like to see. Sort of like a tattle tale brown instead of a tattle tale gray.

Cameron - Venus was just off the edge of it. I have the report of it.

Schirra - Let's see, where are we there?

Cameron - I don't think you are saying anything about that. I was wondering if you noticed Venus at that time?

Schirra - There was some point in here where I miscalled Venus or Mercury, I forget which, but this is wrong. I told them to correct it and they never did. But anyway this is what I did say. I think you could disprove me very easily, because it just couldn't be there. I forgot which one it was I referred to. Venus and the moon were always together is the whole point, and they were to me in a horizontal line which gave me a good reference.

O'Keefe - Cdr. Schirra, there are some important points here. First of all, of course, both Glenn and Carpenter saw stars underneath the ordinary airglow layer.

Schirra - Yes, I remember.

O'Keefe - So it clearly can't be seen and one would expect that anyway.

Schirra - I would say that this is substantiated by my report of seeing Mercury as it passed through these layers as Mercury set which

would prove that the stars well could be seen going through the same traverse. This thing I saw - let's just call it the smog belt - on this southern pass, to go back and recap the sensation that brought this to mind which is not brought out here other than the fact that I can identify what I saw. I was coming over a land area. (I think I better take a second and break out my orbital map which I have here.)

O'Keefe - If you have the tape, we might replay that.

Schirra - This would be better because some of the nine hours there, I have not identified carefully enough, and I should have, by going back over the tape and these areas of interest - I think we should listen to the original tape again. Let's get down to where we were.

Cameron - Larry (Dunkelman) has listened to it at the Cape, I think.

Dunkelman - Did you see what I call normal airglow at night? That is the soft white band.

Schirra - Yes, I did.

Dunkelman - All right, yes, that's important because I think later it will help.

Cameron - Was that the thing you saw?

Schirra - This is distinctly different and this, I think, we identified in our earlier discussion (speaking of the use of the term airglow).

Dunkelman - Fine.

Schirra - I had moonlight as well, but I could definitely see this faint white effect.

Dubin - Was there any color whatever in it?

Schirra - In the airglow that I saw? No, other than during sunset times where you would have sunlight itself.

Dubin - No color whatever?

Schirra - I think of white as being all colors and you can see I've been trapped with painting a few times. This patch was denser as you came into the middle of this belt. It definitely had to have a light stimulus to it or I wouldn't have seen it. I was well aware of this and thought this as I saw it. The initial impression that brought to my attention is, first off, and this is the liability we have; we're wanting to see something that needs to be seen with the naked eye when the inside of the vehicle is dark.

Cameron - In the patch did you notice any variation in color either horizontal or vertical? Or was it all one?

Schirra - The airglow now we are discussing?

Cameron - The patch over (Madagascar).

Schirra - Oh, this patch, it seemed ... You can't keep track of whether you are over land or water continually and time is progressing fairly rapidly; for example, on this particular period where we are talking in terms of 5 hours and 20 minutes, going back just a few minutes, I am over Africa because I had left the southeast coast of Africa, in other words, Durban and this is the place I had one time in my mind wanted to see a flare and I did see cities and I know I saw Capetown which was in the clear. I talked to the Ambassador from that section of Africa when we were at Goddard for the 5th year celebration of satellites, and he said, "Oh, I wish we had known that, because

everybody thinks that all you see is Perth! (laughter) Well, we see a lot of other places as well." To go back, I was trying to re-establish this phenomenon in my mind so I had passed over Africa and I was darkened within the vehicle. I was drifting. As I was drifting - we like to say that we can see a city because the people of the city get quite excited about it as we know Perth did - and I was proceeding across the Indian Ocean drifting, so my attitudes cannot be defined, I wanted to say to myself, oh, I see some more cities below me. Now I wasn't convinced in my mind that I was over the Indian Ocean, yet with the attitudes not carefully defined, I might well have seen cities. These I said, ah, those cities are quite constellation setups. They looked like constellations. Then I said, my gosh! they are constellations. They are stars and this was below what I then, in my mind at least, had planted as airglow. Again, a lump term, meaning a lighted horizon, and I looked above this brown smog effect and saw more stars again. Then I could see through this brown effect, stars, but they were dimmed considerably by it. Now, I did not have the opportunity in that the attitudes were dynamic to trace an individual star or planet through this particular area. I wasn't at this point too interested in knowing what constellations I was looking at. In drifting flight, you don't really have a requirement to navigate, that is, to know where you are in relation to a star field or surface.

Roman - So you don't know what you were looking at?

Schirra - So any particular star or constellation, I could not identify at this time. If I needed to, I would then have to destroy

my dark adaptation and light up my star chart and then identify these things. This is the problem we have.

O'Keefe - One of the classic problems in astronomy - one of the solutions for it is to illuminate with a red light, because you don't destroy the dark adaptation so quickly.

Schirra - This is why we went to these fingertip lights which are red. I started out, and this might interest you, I went to the planetarium in Chapel Hill and took both gloves with me. One had white lights and one had the red lights. This was my test of these lights. We used them while working in the planetarium. We lit up the white lights and the whole dome was just brilliant white. These are tiny little peanut bulbs, really minute. This was the last time I used those white lights. That very day - they were painted red as a result of this. You need very, very low orders of light to -

Dunkelman - I had the impression the first time we talked about this that you had not seen any stars through the patch, this brownish patch, but you feel that you had seen -

Schirra - Yes sir, this is what I am trying to do; recreate the scene. That is why I went back to coming off Africa. Having looked for the lights, and having seen Capetown, I then felt that I was seeing more city lights and then I was so surprised to realize that these were stars. Now this only means that I was not pitched down enough to really see the earth itself. So this means that it was quite high.

Roman - Do you feel that you were looking at the airglow layers at sunset or might you have been looking down at this sort of tangentially as you are at some angle?

Schirra - I feel that I was looking up at it now in relation to my local horizon.

Roman - You were actually looking up at it? Have you any idea how high it was above the apparent horizon at that time?

Schirra - That is where I am in trouble, Nancy, because there is no direct repeated knowledge of what this attitude is.

Roman - Well, the other question is ...

Schirra - But I saw a good batch of stars below it which meant that my axis had to be fairly well above the horizon.

Roman - Any structure either turbulent or wave-like?

Schirra - No, this was a very soft - we best describe this in clouds as being a cirrus layer rather than a cumulus layer; a stratus would be a better term, I think.

Nordberg - Sort of diffuse?

Roman - I am still not quite sure I have the answer to my question then. I'm not a meteorologist.

Schirra - If I were to do it, I'd take a chalk eraser and just make a streak across the blackboard, it would be more intense in the center of the eraser and then diffused as I got -

Roman - But no other structure?

Schirra - No other structure.

Roman - The reason I am asking this is that it sounds as if it might be related to some other equatorial red airglow which has been observed from the ground. This has a distinct wave structure.

Schirra - I see. No, I did not see the permanent wave effect or the

mackerel effect that you see in clouds. This is very much a - well, I would say if you really wanted to do it - well, do it in water colors rather than chalk.

Nordberg - Did it cover your entire field of view?

Schirra - It covered my whole field of view, yes. That's where I "suckered-in" thinking that I was looking at "airglow-" what we have used now - I think you understand how I have used airglow and that there were cities below it and stars above it. Then, these cities were defined rapidly as stars and then I -

Dubin - You actually saw no horizon then? And you saw none of the regular airglow?

Schirra - No, I could not see any vestige of the surface of the earth, meaning the true airglow in this sense.

Dubin - What you saw then were some of the bands with stars above and below - you remember how high up you were looking?

Schirra - No. If I had not had the fetish of conserving fuel in this drifting period - was most important - not only conserving fuel, but to see what effects the vehicle would get while it drifted over a period of time; in other words, what this minute atmosphere might do to the vehicle, whether it would spin it up or slow it down or what have you. I could have picked up my attitude just by pitching down and picking up the surface of the earth. But then I would have destroyed the period of time that we had been drifting to see if the vehicle attitude had been affected by the orbital period.

Roman - For something like that, would it be desirable to carry a small mirror, something like a woman's pocketbook mirror, which you

could look down at the different angles.

Schirra - We had a mirror on there. This permitted me basically to look toward the heat shield. Something like a rear view mirror, except it was a front view mirror in Mercury. But in any case, you almost need - we need something like a dental mirror to move around. I think again you get in trouble with a mirror; I considered this. In fact, I had a mirror on my hand which was a flat plate much like the woman's cosmetic mirror. It was about the same size, and when you use a mirror you lose so much just by the fact that you change distances. Your image has been ranged differently. So I found that I didn't have any luck at all.

Tennyson - It was just your disorientation.

Schirra - That itself was another problem. (Cameron showing Schirra a drawing)

Cameron - I have a drawing here of what I think you saw out your window at 5 hours 20 minutes.

Schirra - Oh, really, I'd like to see that, yes. ...

Cameron - It's just the star chart. I tried. ... I think this is where you were, well, I made a tracing of the thing and slid it (the plastic slide which represents the capsule window) up (on the star chart) here - here's the horizon and I tried to guess where you might have been, and I put the width about ... (showing Schirra) you thought it was -

Schirra - Very good. But the thing is you see I could be tilted as well in roll and it would move this field--see what I mean?

Cameron - I was wondering if you recognized this pattern here that you saw below it?

Schirra - What really flipped me--this is where I got in trouble--I said something about the Pleiades and I know I could not see those.

Cameron - You see according to this the Moon was up at the top (of the window) and Venus was off to the left. Did you see them?

Schirra - I did not see them during this period, no.

O'Keefe - Where is Delphinus? Delphinus is somewhere.

Roman - I was just thinking about that. ...

Cameron - Well, he's in Ophiuchus and Hercules and --

(General discussion which is inaudible)

Schirra - Delphinus does look something like the Pleiades in a sense, yes.

Roman - It's a little larger, but I'm sure that...

Schirra - At one time I tried to trace this down and see what I really was looking at and I frankly have not done it. This is typical of everything we do, we always rushed into something else.

O'Keefe - (to Cameron) Can you find Delphinus? It's right next to the (Northern) Cross.

Cameron - I don't see it. I don't think it's on here. ...

Schirra - Did I identify - when I said Aldebaran, I may well have been talking about...

Cameron - There's a Norton (Star Atlas) in my bag - maybe I'm - if you'd hand it to me - maybe I've got the wrong page--I don't know - I don't know why - he's got it there very clearly.

O'Keefe - You have Ophiuchus, Hercules?

(Conversation inaudible)

Schirra - I used to carry my little star chart slide rule thing around with me.

Roman - Alternatively, there are some (star) clusters - well, if it's the Pleiades, it would be well enough defined and you wouldn't confuse it - there are some clusters in a star field which at first glance give you the same haziness that you get from a cluster like the Pleiades.

Cameron - It's the wrong direction, of course.

Roman - Well, but he is down in the Scorpio region if you think of it.

Schirra - One of those things I do recall very vividly was that I talked about Aldebaran and it just couldn't have been there at the time I. ...

Gill - O, well maybe you didn't have the Pleiades then.

Schirra - I know it wasn't. It wasn't the Pleiades.

Gill - Because you've got Orion here. Orion, the Pleiades and Aldebaran go nicely together.

Schirra - They sure do, but they shouldn't be there.

Gill - But those were the wrong ones. (Laughter) They can't be there.

Dunkelman - I think Voas corrected that at that one time. You see Aldebaran wasn't there.

Schirra - Yes, this is the liability you get into if you don't really know your attitude; with this star chart you can sweep out a whole new segment of the sky.

O'Keefe - Why can't you have seen Aldebaran and these other things? Were they above the horizon?

Schirra - I don't think they are in this area. We have to expand this star chart. Now if I were yawed around 90 degrees, this star chart is absolutely worthless because this only goes a plus or minus 60 degrees.

O'Keefe - I know, I know ...

Schirra - Maybe I could have ...

O'Keefe - But, your flight path did go over Aldebaran, Orion - the plane of the orbit.

Schirra - As I recall, and my memory of course, is suffering from the time span (which has elapsed since the flight on October 3rd 1962.) As I recall, Orion was on the daylight side, you see it's...

Roman - As I say, I was going to say that Orion was actually very late - just before dawn - if it were up at all.

Schirra - Physically it was impossible to see - here is the constellation Orion way down here - in time, this is on my daylight side.

Roman - I would think that Aldebaran would be much the same problem.

Cameron - Just the same thing.

Schirra - It is right in this same family, of course.

Roman - What time of night was this? Can you give me any idea of the distance between sunlight and sunset?

Schirra - That's why I am perfectly convinced that I could not possibly see anything associated with the constellation Orion or Aldebaran. With this star chart, Nancy, what we do is have a time margin. (Looking at the chart.) Now Orion down here is actually in my local daylight. It just was impossible for me to see it at this point way back here. It was occluded frankly by the

surface of the earth; physically, I just couldn't see it.

Roman - That's what I meant when I said at best you-d see those just before sunrise--if at all at this time of year.

Schirra - Right. It was just impossible for me to see it at this point way back here, so it was occluded by the surface of the earth, frankly, I just couldn't - physically I couldn't see it. What really would be fun, by gosh, would be to go back up and have Tony Jenzano (Director, Morehead Planetarium) lay this out in the planetarium.

Gill - Yes, yes, you ought to be able to solve that.

Schirra - I would be able to tell exactly what I saw. I'll do it - That's the way to solve this because then I can get the whole star field, the complete celestial heaven at this time and space. And then we can make some points. I think one of you should go there with me so we can have this pinned down. I think we should lay this out. He (Jenzano) can lay out the whole flight plan.

Gill - To get it pinned down.

Roman - I would say here that Arcturus or Antares could have been confused for Aldebaran here.

Gill - Absolutely. Those would be good candidates.

O'Keefe - Let's not let this point go. Who should go?

Shoemaker - I think we should plan to do this.

Schirra - I think this is the way to answer this rather than trying to beat it to death. I'll bet I'll be able to give you a whole bunch of information in there (at the planetarium).

O'Keefe - Should it be you, or Jocelyn?

Gill - It depends on when it comes off - what time it comes off.

Shoemaker - Why don't we say we'll plan on this and then we can make the arrangements --

Schirra - I am afraid that I can't do it rapidly, but I'd say the first part of April would be okay.

Shoemaker - Jocelyn, would you like to take this on to set it up and follow it through?

Gill - Certainly.

Schirra - I would like to nail this one down. It has been bothering me for a long time and I just don't seem to be getting any answers that I would like to have as well.

Gill - It is possible to have hindsight here. In other words, we can reconstruct the crime and it is worth doing, I think.

Dunkelman - I am glad you mentioned that you could see some stars dimmed through this patch because-if you don't see any,-the patch turns out to be extremely bright.

Dunkelman - It's about 300 times higher than what the normal airglow (seen) edge-on is.

Schirra - Well, it wasn't dim by any means.

Dunkelman - It wasn't dim - the answer I get is that it is about 3 ergs/cm^2/sec which is extremely bright and its structure is extremely high. It is about three hundred times brighter than the normal airglow. I think we can "home-in" on this brightness rather nicely because, if you saw color, you know it is a dirty brown, but if it was color, that does require at least 50 to 100 times more than the normal night airglow.

Schirra - That's why you were asking me earlier was there a color

in the airglow and I did not see it?

Dunkelman - We are trying not to - (influence your reply).

Schirra - Playing one (response) against the other is indeed a good way of doing it.

Dunkelman - Another think is that this was indeed brighter.

Schirra - But, well below. ...

Dunkelman - It is possible that the normal airglow was there - but you didn't see it?

Schirra - It was well below my field of view though.

Dunkelman - But are we sure? I assumed that it was well below, too, but...

Schirra - Yes. I saw what amounted to a clear starfield below this...

Dunkelman - About how many degrees worth though?

Schirra - I was just trying to think - Well, the window itself - I'm just trying to think what I can see degrees-wise-this is -

Cameron - Thirty degrees.

Schirra - It was roughly thirty degrees.

O'Keefe - But there is a trap here because that window shapes out at such a steep angle - that if you attempt to estimate height by estimating portions of the window--

Schirra - Oh, no, I wasn't doing that. All I am trying to say is that in the window - included in the window - let's forget this smog band, it were stars only, it was below the window which would be the earth. There was no horizon and even if I could have been inverted, we could just say that the window would be this way. There was still no earth vision, nothing of earth I could see, including airglow or

anything else. So I was strictly looking, if you could almost say, I could even be looking straight up, which I know I wasn't. The stars were equally bright and equally in number almost on either side of this band.

Dubin - It was about through the middle of the window?

Schirra - That is correct. I went even as far as to say that it wasn't a third of the window and then I modified this down to a fourth, but it was more than a fourth and less than a third. This means, in any case, that it's approximately ten degrees thick and this is a very rough estimate.

O'Keefe - It wasn't the Milky Way?

Schirra - No. No, I like to look at the Milky Way so I've seen it enough to say "no."

O'Keefe - Because you were facing according to your picture to - well - no - Sculptor, Fornax - no -

Roman - The Milky Way in that part of the sky, should have a very distinct rift down the middle, it wouldn't be brightest to the center and shading off.

Schirra - Yes, in fact, if I recall from the way we ran the planetarium, the Milky Way was almost on my horizon.

Dubin - How long can you see this by the way?

Schirra - We can do this too, John. They have the Milky Way projected on this chart. It is a very fine tool, I might add, particularly when you want to reconstruct the crime.

Gill - Might be very good practice afterwards for the pilot to go

back to the planetarium (to reconstruct his flight path.)...

Schirra - I sure wish I had thought of this a long time ago when I was fresher on this.

Gill - It would fix things in your mind too - you'd be able to see them again right away to pin them down.

Dubin - How long did you see this?

Schirra - I would not say seconds, I would say minutes.

Nordberg - Did this go away simply because of your progression in orbit or because of your drifting?

Schirra - I think more because of the drifting, perhaps.

Dubin - Did you see the stars through it?

Schirra - There again, I didn't have time to track stars through it. When I say minutes, I don't mean a whole bunch of minutes, I mean one or two or three minutes.

Dubin - Yes, but do you know whether you saw stars moving relative to the band?

Schirra - No, they weren't. It wasn't relative to the band. That's a good question, now that you bring it up.

Dubin - In other words, the stars seemed to stand still.

Schirra - The band and the stars were planted together, much the same way as you would see the Milky Way in a sense. That's a very good point.

O'Keefe - You saw a bunch of things there. It might have been Aldebaran or it might have been Antares.

Schirra - I suspect that is what I did see at Antares or Alpheca, and I think that is in that same spectrum there. I think rather

than beat this any further, it's circumbent on us to go to the planetarium and really nail this down. All I have to do is just take this window box we have and just move it around and - ah ha - there it is.

Dunkelman - Something we would like to know is the dimming effect.

Schirra - Uh huh.

Dunkelman - You say that this patch was quite bright, that's one thing, and then was it quite bright because it appeared bright or because there are many, many fewer stars. This is the question we have to answer.

Schirra - Right. You know what went through my mind when I finally realized what I was looking at? I was livid about the fact that I had the periscope. Absolutely livid, because I would have shot up a whole roll of film right on that (using uv spectrograph). (Laughter) I was fighting for that thing and that's why you can look through and I make perisocpe sound like a dirty word. All through here the word periscope is shortened to four letters practically. (Laughter)

Shoemaker - Why don't we go on. Jocelyn, why don't you get together with Cdr. Schirra and write a conclusion on this.

Schirra - We'll set up a rendezvous here.

Shoemaker - I think we have covered quite a few of the remainder of the questions partly in discussion. I would like to go back to dark-adaptation here which is the next question. You have talked about it and let's see whether there are any points that we haven't covered. The question is would you tell us when you think you were best dark-adapted? Was there any time during flight when you employed only red light in the

capsule?

Schirra - We have answered that with the fingertips.

Shoemaker - Did the light of the "time-correlation clock" shine in your eyes throughout flight?

Schirra - The answer is no. They put in a switch to turn that off and I turned it once and it was never turned on again. This was a very great annoyance. This was my prediction that I would turn it off and never turn it on again.

Gill - You were responsible for having the switch put in, weren't you?

Schirra - Yes, I went through some very careful studies on the darkness of this interior. I ran a special test at the Cape and it is amazing how much light comes in there. John and Scott were surprised when I told them this. Scott came back from his flight furious about this time-correlation clock light. So I put in a switch-in-series and just clicked it off as soon as I got to the switch.

Gill - Good for you.

Schirra - It was the first time it was dark outside, frankly, and that was the end of that light. (Laughter) The cabin lights are tube lights. They leak like mad. Just terribly. So I turned those off as well when I wanted darkness. Then I had pure darkness. The only light I could create then were the fingertip lights. When I blacked out that capsule, it was black dark other than when I needed to see something with the fingertip lights. This is where our crutches - as I described the map, the time and the star charts

became a liability, because we had then to bring on light again (I brought on the finger tip lights to do this). Gordon knows how strongly I feel about the star chart device. This is a valuable tool. But it required two tools and a slider. Actually, two tools, with sliders on each to use them. I had to take one tool which gave me a reference in the time that had elapsed to come back to the star chart which had a reference for one time - I think it was an hour's worth. So I had to come over here and compute. For example, say I had 5 hours and 20 minutes, so I'd run down 5 hours and 20 minutes and look across and this is equivalent to say 53 minutes. So then I would say, Ah, 53 minutes; so then I would race over here and set the little window thing on the index of 53 minutes and this thing is floating around and I would stamp it off and get it out of the way. This is quite a chore. It really is. So now we have included this on the flight plan itself, what index of the star chart to use. So we have simplified this task quite a bit.

Cameron - As far as the star charts are concerned, fluorescence --

Roman - Suppose you had an ultra violet lamp in the capsule -

Schirra - If you kept it up?

Roman - That's what I was going to suggest --(fluorescent paint on charts) Not depending on storing it up and letting it go down afterwards.

Gill - You mean keep it on?

Roman - Well, depending on which looks more desirable. But you could set that at a level where it would not blind you and

and you could see what you needed on the chart.

Schirra - Now this could be practiced in a planetarium.

O'Keefe - There are plenty of fluorescent inks.

Schirra - This star chart thing was a real problem even to get it to the degree of refinement that I had.

Gill - It has a white background now?

Schirra - We had to take the surface and sand it in a sense to get it non-reflecting, because that was a problem.

Dunkelman - I want to caution you on that ultra violet light, though. It has to be very carefully designed, because if just a wee bit of 3615 leaks out of it; your eyeballs fluoresce. It must be carefully done.

Schirra - I've become very interested in this as a problem in that on the Apollo mission, where you will need to find particular stars, we should have some kind of star map that you can see without blinding yourself. Those fingertips to me were awfully bright.

Roman - You can't turn it down?

Schirra - No.

Gill - You must have been well dark-adapted?

Schirra - Yes, that's right. I feel very strongly about this dark-adaptation, by the way. I have felt this way about this ever since I have been involved with this. As a night carrier-pilot, it was always a problem as you know. We would sit in the ready room with red lights on and red goggles on and we then would go roaring up to flight deck and there would always be somebody there with a white light to shine right in your face.

Dunkelman - The Navy has done this very carefully.

Schirra - It can be destroyed very rapidly. It turns out quite frequently when you are in a cockpit and you're time-critical, more so than when you are on a carrier deck for a night launch than when you are on the pad. Things are in a frantic tempo. You make a very rapid checkout of the cockpit and you really don't care about light adaptation. You just want to be sure that everything is in its proper position. So all of a sudden--boom--you are shot off into the black and surprisingly you are very well adapted. I feel--I know Scott has made a test on this--I think you come down to a very rapid adaptation in seconds and then you progress getting better dark-adapted over many, many minutes. I know this has been documented. It is not worth trying to adapt to this exponential curve that you are trying to get hold of.

Gill - Five minutes certainly helps a great deal.

Schirra - I have said this in the past, for example, if it were night outside right now, we could step outside that door. With this lighting you have in here, you can see outside this door (assuming you are looking at the celestial night). You can see more than I could see out of the window of the capsule with perfect adaptation. I have done this. I have been in a lighted room since the flight and have stepped outside. Now we have done this frequently at the various control stations around the net. I did this at Guaymas which you well know is a tremendous place to look at stars. I walked out of a room just as lighted as this and got outside and boom, I saw more than I could see in the capsule.

Cameron - I saw the zodiacal light once doing that in Chicago. I came out of a lighted building. It was the first time I had seen it. It was in a part of the sky where I didn't expect to see it.

Schirra - I think that our test, frankly, that have been conducted to determine dark adaptation are not done well enough. I don't think we can really justify how fast we adapt by the tests we have run. I have yet to see that quantitative analysis made that should be made. Intuitively, I feel that I adapt faster than the test has ever proven to me. We had very complicated systems, such as that at Pensacola where you pick up the horizon and objects, trucks and airplanes and ships,--I'm sure you remember this routine--and I never was sympathetic to this study. I think there is a better way of defining it, however, by having you in an opaque room or rather going from a lighted room into an opaque room seeing what can you see. Have these measured light sources there and then identify them as rapidly as you can. Of course, you've got to keep identifying because you are adapting all the time.

Tennyson - Is it correct then that this window of ours (Vicor window) has never really been nailed down as far as transmissivity is concerned.

Schirra - It has been carefully nailed down, I understand.

Roman - Yes, but not under quite the flight conditions.

Schirra - Well, I was carrying this photometer, and did make some measured readings on some objects, but this comes back to the photometer check on Aldebaran. This comes back to what I really made

it on. I think they are trying to trace that through. It wasn't Aldebaran, that's for sure.

Dubin - You say that you never saw your fluorescent numbers on your watch?

Schirra - No, I did not. This bothered me.

Dubin - Did you look at it?

Schirra - Yes.

Dunkelman - Is this some watch that requires exposure to light for awhile?

Schirra - Correct. There is another answer to this. The time function, meaning just running time, has the fluorescent, but the elapsed time that I used on this watch is just black and white. I wanted badly to get at least the hands coated and this is a real chore. Very few people do this for you. I would have liked very much to have had this done, but couldn't get it.

Dunkelman - I would sure like to see the CIC lighting people have a chance to put their two cents into this whole thing about the lights, for Apollo or something like that.

Schirra - I have gone on record saying that Gemini will not fly until I personally run a lighting mockup on that vehicle as well as on Apollo. There are many people who know how strongly I feel on this subject.

Gill - Very good. Very good.

Schirra - What I'm getting at is, if you can get the light out of the vehicle, you don't need to spend a lot of time adapting.

Gill - Right.

Nordberg - I am curious if you had a chance to observe variations of brightness around the horizon; around as far as possible (during) both in day and night.

Schirra - Again, the field of view isn't that big. I know just what you are asking for. I didn't take the liberty of making these, what would amount to, large yaw changes. I did not have the opportunity to observe that transition. The field of view I had did not show these various changes.

O'Keefe - You see, this is like 30 degrees, that's half a radius. I don't think he could see much more than you could see overhead at night.

Schirra - Yes.

O'Keefe - It means that if he doesn't see patterns in the airglow from a single place at night, unless he has the freedom to yaw all around, he doesn't have the opportunity of tracing out the rather large patterns which must be in the airglow. They are of the order of a thousand miles in diameter.

Nordberg - I was also curious about daytime, because of the forward scattering and backscattering and 90° to the sun and actually, in daytime if your turnaround maneuvers are, say, they don't go around in a plane tangential to the surface of the earth? They go around in a radial plane, don't they?

Schirra - Well, this is the awful thing about our vehicle. All the thrusters are not aligned through the body axis, therefore, you get two and three axes when you ask for one. If you were trying to track the horizon, using the yaw input, say the horizon being like an arc here, you go like this. Then you've got to roll,

pitch, like this, roll, pitch. In other words, you step your way around. It is not a smooth maneuver as you would anticipate in an airplane where you just roll and come around and cut a swathe without changing attitude.

Nordberg - In daytime, it should be really a striking thing, the horizon looking toward the sun and, on either side of the sun, and also looking straight away from the sun it could be extremely bright ... and at 90°.

Schirra - You know where we are going to have the most fun? It's with the lunar module - the LEM or the Bug in earth orbit. By gosh, that's going to be great, because you practically have an observatory on your hands. A lot of open panel area that doesn't have to be protected for re-entry or exit. That will give us our first real opportunity to look in almost any direction at any time. You should see the fight we had, to keep a 5th window in the Apollo command module. They were about to rip it up and save 16 lbs. It was in the right seat where you spend 90% of the time on a trans-lunar trip. (gasp) Negative. (Laughter) We said no so we had a seance, that's what we call it. This is when we get a majority of the astronauts together and we agree. If there are any dissenters it is just too bad. If they are in the minority, well, we come out with a united opinion. This is how we got our window in Mercury. It was the result of a seance--it cost $500,000 and I think you know its worth it. It was for observation not only getting attitudes.

Schirra - These things you can't define by numbers. In spite of what my philosophy was for this flight you can't resist making scientific observations. That's taped? I think it's legal.

Gill - That's what I thought--You wouldn't be human if you didn't.

Nordberg - I would like to get away from the horizon now for a moment. This is going to clouds. There have been reports by all five of you on seeing cloud patterns and the like; is there any good indication when you look down of on depth cloud?

Schirra - Very much so. You can get Paul Backer (try Charles Coler, MSC, better) to give you the Weather Bureau photos I took. It's fantastic what you can see. It is the meteorologist's dream to see this depth, cumulus effect, high cumulus, etc. As an example, I saw the Sierras, I could very definitely see the rising terrain. I was very much pleased. I can best say this by saying, if you've flown at 30 thousand or 40 thousand feet, which you must have, in a jet transport, you see this of course. Now, if the horizon itself is not visible to you when you are looking more towards the surface of the earth, if the curvature of the earth is not visible, you feel that you are at about 50 thousand feet.

Nordberg - And is this because of some sort of stereoscopic view that you can still see shadows and brightness?

Schirra - I think you take every cue that you've got and you differentiate colors by grays, blacks, whites, but there is no doubt in your mind that you see depth and there is one striking picture, this Weather Bureau picture, that shows ten different types of cloud structure. One is a big towering cumulus, almost a cumulus

nimbus that stands out like a ruler in relation to the vertical plane. I think it might be here (in the record).

Nordberg - I have seen some of the films. I don't know if they were your flight or previous ones. I am just curious whether the eye sees something better than what shows up on the color film.

Schirra - Yes, they do. You use every cue available.

O'Keefe - He doesn't have the stereoscopic effect in the ordinary sense, but you remember that he is in motion when he sees that the peak of the clous moves at a different rate so he gets a sort of pseudo-stereoscopic effect like you get when you are driving along in a car-- by the fact that they are moving relative to the capsule.

Schirra - Take page nine here, and put a sheet of paper on the top of it to cut off the curvature of the earth and you've seen this from an airplane. Haven't you?

Nordberg - Yes.

Schirra - That is why I've used it in this example that I am trying to get across. You can see cloud structures in this yellow band here that are just terrific.

Nordberg - Well, how about at night? Have you been able to see any clouds in real darkness at all?

Schirra - Yes, I did and they were lighted by lightning. In fact I gave Woomera a report on the first orbit saying I would not possibly see their flare because I was seeing lightning and they hadn't stepped outside their room. I said that you are about to have some real brutal thunder storms and the second orbit they agreed with me, because they were there then. This was during the night side.

This was sort of interesting because I described the thunderstorm flashes of discharges as blobs of lightning.

BEGINNING OF THIRD TAPE

Schirra - I could not pick up cloud structure because I was looking down and at this point, you don't have time, and I don't think your cues are good enough to separate elevations.

Nordberg - You don't recall seeing any clouds when there was no lightning?

Schirra - No. I don't recall this. I don't think I did really. I was really frantically trying to see this typhoon, and we called it a typhoon where Pacific Command Ship was. It was down south of it, and I could not see it. It was still too dark, and I think the other reason for it was that the periscope - here we go - was annoying to me, that picked up the sunrise before I had my sunrise, because it was looking in that direction, and it ruined my adaptation. That was when I threw the filter over it, and that was the end of the periscope forever. I forgot to remove that filter - not that I even intended to. On descent on the parachute, and in a way I would like to have had the prerogative of looking at the periscope and seeing the recovery forces deployed around there. It took me a long time to realize why I couldn't see the recovery forces. (Laughter). And it finally came out that I threw this filter over it just prior to retrofire. And that was the end of the periscope (laughter) which also showed that I didn't need it, obviously.

Nordberg - This question of frequency of lightning is a real important one. Would you say that you saw lightning through each night time orbit?

Schirra - No, that was only during this area. This could best be described as the eastern half of Australia.

Dubin - Did you notice any lightning while looking down - you couldn't see the flashes away from the capsule?

Schirra - No, oh no, no, I didn't get any light fed into the capsule. It was just my eyes that captured this light.

Dubin - In the daytime did you also see lightning the same way? Did your ...

Schirra - I don't recall having seen lightning in the daytime. It's a good question, though, and I don't recall it. I'm sure I would have noted it if I had seen it.

Nordberg - One question, that I am sure you can't answer because of the orbit of your vehicle, but it's of tremendous importance to the geological satellite people, and this is, the distinction of clouds and ice and snow. I know, you probably never went over snow or ice.

Schirra - I looked up at the Sierras when I was on the second or third orbit - we can pin this down - and I was talking to John Glenn about somebody water skiiing on the Salton Sea, and at this time, it was amazing how much I could see, because this area is practically crisp, clear air in the desert, and I lived there for a number of years, so I know that. I could look all at the Sierras and I could see snow-capped mountains up there.

Nordberg - But no clouds of course.

Schirra - Not, not - well - on the other side of the Sierras, westward there was this terrible fog belt, and I do recall saying sometime I may fly over the Pacific and see the Pacific. I have

yet to do this - in aircraft - in all the times I've been out there - see all of the Pacific. I have never had that opportunity, and I don't know that anybody ever will.

Tennyson - I think what he was getting at is when in the TIROS satellite - the cottonpicker goes over and takes a picture perhaps of stratus deck which to a continual extent runs right up against the mountains that we know are snow-covered - where one stops and the other begins, the snow and the stratus. It is difficult or impossible to tell.

Schirra - No - well, my daytime was, of course, northern latitude, and this was basically summer. I was in the snow-capped Sierras.

Nordberg - This question was really sort of just to make a point, that if ever an astronaut goes into a polar orbit...

Schirra - Yes.

Nordberg - ...or has the opportunity to fly over the ice caps to look for this distinction, because this is something we find we are going to live with.

Schirra - I have flown beyond a cloud deck in aircraft at 40,000 feet and had snow on the surface, and usually trees will come up out of the snow and then make you realize that you are no longer looking at a cloud surface.

Tennyson - Well, our definition of a TIROS Satellite - because of the width of the TV raster - which is just not good enough to pick up trees with the wide angle and the mediocre lenses we use.

Schirra - Well, yes. When you are low enough, you get these terrain changes which helps you too, I think.

Nordberg - There are some thoughts that by polarization and so, one can distinguish it over a uniform surface; of course, the eye doesn't have this, but I'm just looking for a clue that the eye might have which we hadn't thought of in an instrument such as depth, because it's interesting when you say you can see all this depth in the clouds themselves.

Schirra - Yes.

Nordberg - ...whether one could see because of depth difference and shadows, or something, this distinction between clouds and snow. On the first TIROS (satellite), TIROS I ...

Schirra - This thing is stalled out (referring to tape recorder). Is that o.k. Is it finished? - No, no that's going.)

Nordberg - The first TIROS was just sort of an observation when we still were at this "Ge Whiz" stage on satellites. Boy, we see something ----

Schirra - Sure, now you want more? (Laughter) - So do I.

Nordberg - People said look at those beautiful orgraphic clouds over northern India, and there is this huge band, until somebody saw valleys in these clouds and all there was - was snow-covered areas and with the valleys being clear.

Schirra - Very good. ...

Tennyson - John O'Keefe has come up with a statement that I, at least, would like to think about some more and that is the relative motion involved here. TIROS and Nimbus, etc. are still picture-type items. I think his (Schirra's) statement there that watching the tops and bases and of the earth moving at different relative speeds may be, at least, as important to height determination as anything we can

do with spare part items or items like that.

Nordberg - It's again the depth.

Schirra - Well, we are working a movie camera where TIROS is taking stills, is what you are saying.

Tennyson - Exactly, and you imply a height which the eye in itself in a still picture mode can't see, but as it goes you say, ah, ha - this moves at a different speed, and therefore, it had to be higher.

Schirra - I would accept that, except for the photograph I have here which shows this depth. Or is it reminding me of it? I do not know. Do you see the depth I talk about in that photograph on page 9?

Tennyson - To some degree (perhaps), but, no, not as directly. I found that picture interesting, but as indecisive as a good many of these prints are.

Schirra - Well now, do you have all of these Weather Bureau photographs?

Nordberg - I have not seen all of them - well, we may not have them - I find that sometimes it is very peculiar that as a NASA outfit - NASA Center - we often have less immediate access to some of these films than the Weather Bureau has - (Laughter).

Schirra - Well, let's -- I find this disturbs me very much in that when I yielded to taking a camera, I actually did want to take one, but I wanted to make people fight to give me the best piece of equipment they could get rather than just take a camera. I wanted it very clear that those people who could use this data would get

the best print available, and I definitely have this group on that list. For one, I am disappointed that this occasion where I pulled this Weather Bureau filter out of the back to take these two pictures of the moon, I have heard and I have yet to have seen the graphic results of those two black and whites on the moon, which are quite interesting to a lot of people. I have heard this. Now where they've gone, I don't know. Although I know they can be obtained again, I thought this was a shame.

Tennyson - I don't think that I have ever seen these prints. And, we are in the office that supposedly collects the requirements for meteorological satellites and I have not seen the direct prints of this. The only thing I have seen come out --

Schirra - Well, I have heard that if you take - and I haven't had the prerogative either - if you take the motion and project it on a very good screen, it is really something to see -- at least of these two lunar pictures. And that's why I took the Hasselblad. To take this big piece of emulsion - the 70 mm film rather than a 16 or 35 mm. - and this I do know about photography that the larger the strip of film, the more you will get out of it. That's why we went first class with a Hasselblad (camera) and why I am not at all in favor of taking a 16 mm. camera along which is what we are using.

Nordberg - We had, in the early days, right after MA-6, we had written to Kleinknecht and had gotten periscope film, which, you know what the quality is, and we got always the answer that they

don't have the 70 mm. yet, but as soon as they become available, they'd send them to us, but actually we haven't really received anything from them since and the only time that I have seen some of these photographs that you are talking about ...

Schirra - Well, Kleinknecht doesn't have control of this, MSC doesn't have control of these pictures I took, obviously, or actually I would have been able to see them.

Gill - Who does?

Tennyson - The person involved with this (at least in the past) is Stanley Soules.

Schirra - Yes, when you think of the small number of pictures I did take, and the expense that was involved in taking these pictures, it is just amazing that first class reproductions haven't been disseminated widely.

Shoemaker - I think, Jocelyn, this is something that you and I and John O'Keefe should take up with our joint committee.

Gill - I'll look into it.

Schirra - They should be all over the place ... is really what I am really getting at.

Shoemaker - This is something we can do something about.

Schirra - Sure. I know Kleinknecht can't help you with this because he has no control over this.

Shoemaker - I think we can straighten this out.

Cameron - Did you ever think you could see highways?

Schirra - I saw roads in areas such as Mexico where they disturb the terrain by being in a straight line. I never did have the

opportunity to see a highway, for example, and trace it, because I wasn't over those populated areas such as the Southern United States long enough or had the clear weather to just sit there and observe them. In contrast, I think what you would do if you saw something and wanted to look at it, I think what you would do is that you would pitch down more - to look almost straight down and see it which Scott had the capability of doing and he could really take a careful look at it.

O'Keefe - One curious fact that I haven't seen anybody take advantage of is this. It is quite common in triangulation - that two stations which are a couple of hundred miles apart, or a hundred miles apart, and that therefore as far apart as you are from the ground and along a light path which is much inferior - it's nearly parallel to the earth. In order for one of those stations to see the other one - to measure on it - they provide one of them with a 6-inch heliotrope, that's enough. That means that somebody on the ground with a six-inch heliotrope who knew how to point could point a light that you could see even in the daytime if they had a dark background; and conversely, if you had a heliotrope, you could also be seen from the ground. I have never seen this possibility discussed. Of course it also goes with the fact that instead of these tremendous flares, if they knew how to point, they could make a much stronger light where you are with a search light.

Schirra - Sure. ...

O'Keefe - The army 5-foot searchlight gives 800 million candles

on the axis which is easily the equivalent of 800 million candle power...single flare on the ground ...

Schirra - uh - huh --

O'Keefe - Well, I think 2 or 3 million is the biggest thing they ever tried to use. So the directed beam has quite a big advantage over the undirected beam, if people's orbital work is good enough.

Schirra - Agreed. Our problem of course, is unless we have the window, meaning, of course, attitude, fairly vertical in relation to the surface of the earth, you can't take advantage of this. This is just the confined attitude that we've been flying in. ...

Shoemaker - I think this bears on another question that was submitted. I might read it and find out what else we can add to it. The photographs of terrain were not successful. Some of the trouble was obviously due to cloud cover, and some of the film was over-exposed. Can you comment further on this, and do you have any suggestions for successful terrain photography on future flights?

Schirra - Yes, I do. I used a BIWI automatic light meter which is still ideal for the job, and again we were not briefed carefully enough on the BIWI automatic, and if I had this to do again, I would get the manufacturer from BIWI to come down. In fact, many things I've talked about for equipment, I would not ever -- I said this years before this flight, but while on the program...If I needed some information on the capsule, I would not feel adverse to calling Mr. McDonell (McDonnell Aircraft) down, as an example. If I had a BIWI exposure meter, I would like to have Mr. BIWI or whoever is

the man to brief me on it, and I since have read up a little bit further on this exposure meter and there is a little soft, white cap that goes over the eye of the exposure meter which takes diffused light. It doesn't change the light meter reading, but it basically then takes an average of all the light it sees. Now when I was using it, I didn't have this cap on there and I then got the brightest light of some area and that's why we overexposed the film.

Nordberg - Yes, yes ... it's very simple...

Schirra - It's as basic as that, and that's why I over-exposed these light values that I came back with and which were recorded are really of no great value because of this, I think. It's a small focus - the exposure meter is just about that size cubed (demonstrating) it's a beautiful little piece of equipment and quite accurate. We had a calibrator, but it should have been (capped) ... Gordon Cooper knows this and will have a cap on his, I might add.

Nordberg - Have all pictures been overexposed?

Schirra - No, I looked out on occasion where I would be looking at an almost uniformly lighted area such as the surface of the earth. When I had the horizon in the picture, we usually overexposed because I had two different light levels.

Dunkelman - Well, the pity of it all is, since you do need an exposure meter to get a good picture, and exposure meters give you a number, it's too bad the numbers isn't available.

Schirra - I did record these.

Dunkelman - Sooner or later these numbers are going to give you a

lot of information about these flights.

Schirra - That was my intent in taking the exposure meter and the Hasselblad because you took light values rather than F-stops and shutter speeds and this means nothing... those numbers. The light values connote exactly what you want to know.

Dunkelman - And a few of those and you've got it all made and you know all the circumstances.

Schirra - Cooper will have this very same type of light meter.

Nordberg - You know why I asked this question, Larry, because we are measuring visible radiation in one channel of the TIROS satellite which is essentially the same thing as an incident light meter measuring in one direction and when we compute the reflected energy from the earth, it always comes out too little which is the same thing as overexposed pictures.

Schirra - Sure, Sure. It just depends on how much it sees. If it sees the horizon, it's going to have some black in there relative to the bright surface of the earth, so it averages it out.

Shoemaker - I'd like to add some questions of my own to this. You were over Africa during daylight on part of your flight, were you not?

Schirra - Oh yes.

Shoemaker - And how about Australia? Were you over there during daytime at all?

Schirra - No, never having daylight over Australia.

Shoemaker - I am curious as to how much detail you could see on the

ground as to structure. Could you infer anything about it?

Schirra - Amazingly enough I felt I saw every bit of what I see here. The terrain changes, the rivers - one of the best shots - this is of course, South America, that's the one I'd like to use in fact - when I came across South America, here we are, on the sixth orbit, in this area it was all clouded, and I finally broke into the clear - in this sense - just before I got to Rio de Janeiro, and I could see, I think it was the Corono River, I am not sure. This is about where it started clear again. I could trace that river out very easily. Just follow it all the way through there.

Roman - To the ocean?

Schirra - No, I could not do that. I thought I could, but at this point, it's sort of a local sunrise, so you don't have good vertical lighting on it at this point. Now in Africa, I had vertical lighting almost. This was almost its local noon when I crossed it. I would like to have seen this large lake right here almost in the center of the mass of Africa, and I don't recall seeing it.

O'Keefe - Chad, Chad.

Schirra - Yes, I think this is probably when I was conversing with Conno and we had quite a bit of discourse about the suit circuit.

O'Keefe - Chad is a very tricky lake anyway. Lots of the reeds in it, and it is very shallow; I think sometimes it just isn't there, so ...

Schirra - I think you just simply get a light reflection off it possibly. It looked so pronounced here that I wanted to see this as a check point and had it in mind, and I've forgotten ...

O'Keefe - I think this is swamp and it's very shallow.

Gill - You never would see it then.

Shoemaker - In photographs I've seen from previous flights, both Glenn's and Carpenter's flights, I think we got some pictures on Africa, and I was quite interested in these because they begin to show up the structure, the bedding, etc.

Schirra - Yes, I was looking for this particularly over Africa and South America because this was supposed to be real prime in transition on the northwest part of South America which was really a beauty when you visualize how you hit that with the 6th orbit, and I didn't have that prerogative either. Yes, when you come down to it, this was all primed for geologic study, I thought ... Even Cuba was hard to see. (Laughter)

Cameron - Did you see anything on the order of craters?

Schirra - No, this is not the map I flew with by the way - sort of blocked out for specific attention. I frankly was very disappointed about the cloud cover. I think you've detected that anyway. That doesn't go too far North and South you are in this tropical zone which is the cloudiest part of the earth.

Schirra - Yes.

O'Keefe - It is most systematically cloudy. If you can go just a little further north and south, the chance of getting this weather will be better, although this would probably always be true, just as you've said, that most of the earth at any one time will be cloudy. This belt goes from about 35 degrees North to 35 degrees south. You didn't quite get an inclination of about 33 degrees.

Schirra - As an example, I was hoping that I could look up at Japan after retrofire, and I couldn't see it at all. It was clouded in too.

Tennyson - Japan, this time of year, looks like it would be cloudy.

Nordberg - Particularly at this time of year - this was October, so that was already in the Northern Hemisphere and should be out of the tropical convergence zone.

Tennyson - But still Japan by nature is .... (cloudy)

Schirra - There was quite a bit of weather in the Pacific at that time.

O'Keefe - Still, if he goes 28 degrees N to 28 degrees S, he was in the tropical convergence zone most of the time. So things aren't quite as bad as they would appear from this flight.

Shoemaker - The point is that this also is in the area which is mostly extensive deserts; these are the precise areas where you would see the geology best.

Schirra - Yes.

O'Keefe - This is 30 North and 30 South -- the deserts are 35 degrees.

Shoemaker - Well, actually the extensive deserts nearly all lie in (interrupted)...

Schirra - Something I'm curious about is, I would like to have somebody - well there are two ways of doing this - I bet I probably had water underneath me about 90% of the time.

Cameron - About how much cloud coverage would you estimate? Would you estimate the amount of the earth that was covered by clouds?

Schirra - I guess I could check this more carefully. I would

estimate it to be about 80 to 90%. When I went over - the United States was clear east of the Sierra's, but it "sacked in" (clouded over) again by the time I got to the Gulf of Mexico, so I just had a small band when you look at this part of the United States. This is not very much percentage-wise. South America, I didn't get to until the 5th and 6th orbits, so I was over water all the other time. The northsic portion of the continent was cloudy and finally I got into the clear on the 5th and 6 orbits by the time I'd just left South America. Australia, of course, was night, so it turned out that there wasn't much I could say about it. Other than the fact that it was clouded over too. I saw lightning as I got to the eastern half of Australia.

Gill - You never saw any large view of water then? In other words, you didn't see any part of an ocean?

Schirra - No, I expected to have some fun looking at shorelines. This is what I really wanted to look at, to see if I could see color contrast and even the Pacific Islands. I had hoped to see the Hawaiian Islands which would have been a real easy one to pick up, and I think I had one little glimpse; about as much as if you'd fly 9/10 cumulus structure and you pop one through there. That's about as much as I had and I couldn't even identify which Island I was looking at.

O'Keefe - Probably Haleala or else ...

Schirra - Might have even been Hawaii itself, I am not sure, which is probably the highest of the bunch, and it might have popped up through it.

O'Keefe - There's a 10,000 foot peak (Haleaki) or Maui.

Dubin - How were you overall set for time? You were up to the sixth orbit and you had some trouble with your suit, so we found out. Did you have time to basically do more scientific work than you had the privilege of doing?

Schirra - I think as we - and this is the trouble with Mercury because this is just about phasing out - as you get your confidence in the systems to where you don't need to monitor them as often, you could take time for observation. But you continually, at this stage of the game, cannot rely on the systems running themselves and so you keep carefully monitoring these things. This draws your attention away from, say a five minute observation. The only time that you could make a lengthy observation would be when you are under this automatic control when the capsule is maintaining its attitude for you rather than you trying to maintain it. This is very hard to do; to maintain a capsule attitude. In that it's a three-axis motion everytime you make one motion because each one is influenced by another axis thrusting. So as a result, it gets quite expensive fuel-wise to point your field of view at an object. You have to sit there and just steam around like mad to do this.

Gill - Would you say that you ever had as much as five minutes at a time to look out of the window?

Schirra - Oh, yes. I think I took a fairly long amount of time for example; observing this particular sunset that's representative of about three or four minutes. Even then, you keep checking things to see if what you see is really what you are seeing. For example,

was that really Mercury? Well, I knew it was Mercury just by having had the opportunity to have Mercury projected on approximate launch day, so I knew it had to trail the sun, and everytime we ran the planetarium, we had Mercury projected tracking the sun, on the same path, of course.

Gill - So it is a great help to know what things are there and where they are before you take off.

Schirra - Yes. You've got to have most of this stuff in your mind rather than have to refer to something to remind you of it again. This is why you can get confused as I was, when I was drifting, as what star or constellations I was looking at.

Shoemaker - We have one more question. I think this is rather a trivial one. I don't think we need to dwell on it. Did the moon interfere with your view at anytime, or did you make use of it in anyway?

Schirra - I used it liberally, of course, for attitude reference. One best example, on the third orbit, I was drifting and then restored my attitude during the night rather than during the daytime. We were trying to determine whether we could get the attitude back both daylight and night. Out of the unknown attitude, I first picked up the horizon which was on the night side, very easily, which then gave me roll and pitch and then I had no idea which way to go for yaw. We had no compass ... whether it would work or not is something else. I started looking around at this starfield which was not on my flight path, by far, and finally, Cassiopeia became quite obvious

to me. I said, "Well I, that means I must go left," and as I came left, I started picking up other stars which became known to me through the starfield that I had rehearsed. Then the moon and Venus showed up and that was here.

O'Keefe - It must be very difficult to pick up constellations when you have a starfield to look at that is as small as through your window.

Gill - It isn't ....

Schirra - No, Orion, for example, was not included in the window, so you might see the belt and that's about it, or maybe one or two others in the constellation. That's about all. When you see something like Aldebaran, and the "v" (Hyades in the Constellation Taurus) - if you just saw that alone, you might very well get trapped, thinking it was the Pleiades, particularly, if you don't have an attitude. You know how well, I know you got trapped (turning to Dr. Gill) when we went into the Planetarium for the first time - things were inverted for you?

Gill - Oh yes - yes, indeed.

Schirra - When you have an unknown attitude, the star picture is bent out of shape. You can get into trouble fast.

Nordberg - I had a heck of a time the first time I was in Australia; it was difficult to recognize anything.

Schirra - Isn't it! Yes and when we aren't changing attitude and even when we know the starfield, it's not changing once youv'e seen it on the first orbit. So I was sitting there with the star

chart, bending it around. (Laughter)

Gill - It's very hard to get oriented.

Dubin - Did you or Glenn or Carpenter see any meteors?

Schirra - No, and we were naturally anxious to see them. I understand some little Japanese boy picked up one recently (Comet Ikeya). Isn't that right? That was a comet and we were looking for meteors and comets and we never saw any.

Dubin - And so you never saw any?

Schirra - So I suspect that you have to see the meteors from the surface of the earth.

Dunkelman - No, again the field of view is too limited.

Schirra - Again the odds are pretty grim. You take this little window and you project it through 180 degrees, and it's pretty hard to see anything. That's why I say this lab (lunar module) is going to be fabulous. It really will ... That's practically a bird cage.

Nordberg - How about the brightness of the sky looking as straight out as possible in the daytime?

Schirra - I have asked Gordon to go ahead and do this again and concentrate on it. I did not, but in my recollection, I did not see anything in the heavens on the daylight side. I think what did this was the reflections off the window with this smoked over effect which made it even less visible. This film - back to the windshield thing - where the smoke is condensed on there - under the right lighting conditions you can barely see through one of these things. That's basically what happened there.

Nordberg - How about color? Was it very dark blue?

Schirra - Oh it went from blue to black. Not an appealing blue by any means.

Dunkelman - Well, really to be fair to an astronaut, one ought to take a replica of the window and go in the dark room and illuminate it side-wise with a xenon arc or a solar simulator or something that will come near it and then look out and see what you can see, and I am afraid that it is going to be pretty miserable.

Nordberg - It worked well in an experiment.

Dunkelman - I think it should be done ...it's the sort of thing you should do.

Schirra - We continually do this in airplanes at 50,000 feet in daylight and the sky is quite dark. It's very dark to you. It turns out that all this incident light that's reflecting around this panel - just because its plastic, it feeds light through it much like a fibre optics system and becomes a glowing panel that you are looking through here.

O'Keefe - The full moon which is as "black" as ... yet we all know that the full moon just about blasts the sky. That means that if when you are looking out of that window, you see any object which is illuminated by the sun, and which is as big as one-inch ten feet away, you've got the equivalent of illumination by the full moon in terms of you know, disturbing your adaptation.

Schirra - Oh yes.

O'Keefe - Even if it's painted black and of course, you are not likely to be that lucky ... you are likely to have some nice, bright

gleaming thing.

Schirra - The only opportunities I had for looking vertically were during boost and re-entry and a lucky chance while drifting.

O'Keefe - If you are going to observe during the daytime, the whole window has to be turned so that the window doesn't look at the sun and so that it doesn't look at anything that looks at the sun and so that it doesn't look at anything that looks at something that looks at the sun.

Schirra - Right.

Tennyson - Otherwise, this would imply that to know with reasonable exactitude what is being photographed through the window in terms of spectra or anything like that, you'd not only have to know the transmissivity of the window spectrum range by running it value by value across it, but you would have to know what was on the window and what the angle, the incident, sunlight and everything else were because some of this is going to wind up inside on the camera.

Schirra - Right.

Gill - So, you didn't go through the periscope hole, you say?

Schirra - Basically, you were ...

Tennyson - I was talking about these weather bureau pictures ...

Gill - Oh you were ... those weather bureau pictures, oh well ...

Schirra - Where we are trapped really is that we can't duplicate what amounts to being in the bottom of a well.

Tennyson - Well, I understand.

Schirra - That's the whole thing.

Tennyson - This isn't a criticism ... it's just a comment really.

Schirra - That's our liability with the window being on an external surface. You are that close to the top of the well, so you get incident light all over the place.

O'Keefe - We don't want to create artificial problems here. That smoke scum on the window would not really disturb a stella spectrum because the absorption would be broad hand and would not be confused with the stellar lines.

Dunkelman - That's right.

Tennyson - I was thinking about the IQSY photographs.

Schirra - Yes, yes.

Tennyson - We are going with the problem of, oh, the ultra violet and what is going to fog our nimbus pictures so to speak through these photographs, well, the same still unknown film on this thin (capsule window) being reflected in sunlight at an unknown altitude through this window...when you get through, what I'm saying is it would be very hard for us to tell from these weather bureau pictures, etc. (inaudible)

Nordberg - Well, of course, but it's really more an intensity problem-just brightness rather than spectral-I think spectral is not too much of a problem, but the fact that it just dims things under certain angles makes me ... things that much clearer. But this experiment you suggested there is a real excellent one (referring to Dunkelman's.

Schirra - Oh yeah.

Dunkelman - Well, I mean it modifies it even more, makes it better because you can do the same thing outside at night in clear air -

just look at the night sky and then again, having a low level source coming up and even if the window is absolutely clean what happens with these eight reflections.

Schirra - Sure.

Dunkelman - You see, the problem of not letting anything look at the sun or letting that look at the sun look at this is very important even with automatic satellites.

Schirra - Well, I'd be very glad to see it (except capsule window)...

Nordberg - Okay, can we get a window?

Schirra - I think we have got enough used capsules around. I think mine is on its way to South America though (laughter). In fact, its to be there in three days.

Shoemaker - I wonder if we have one last question. If not, we should adjourn. Any further questions you'd like to pose to Commander Schirra?

Dubin - Yes, Commander Schirra, one question, what suggestions do you have for improving the operation over and above what you have already mentioned so far? That's not a very nice question.

Schirra - No, you mean, as far as pursuing investigation scientifically is concerned?

Dubin - Yes.

Schirra - I feel at this point, for example, in Cooper's flight, what we are really trying to do is to get at least man in space for one day. We don't dare compromise that because we need to know how man can hold up for this and we design the capability in the systems.

I admit this is my old pitch, but still he will have a lot of time to do things. So he has a number of experiments on his flight and he definitely will perform these. Now, in my case once I solved the suit circuit problem, I really didn't have many problems. Frankly, none to speak of. But, again to conserve the energy to stay in orbit meaning the control fuel and the electrical power, I had to throw away control attitudes. Once you try to get a control attitude back again, you've got to bring all electrical power back on the line. You have to use a sizeable chunk of the control fuel. This cost us dearly with this weight-limited system. The way to get around this, of course, is to have a larger field of view, since you don't need to move the vehicle as much, and this is, I can already see, the first salvation on this and this is the lunar module in earth orbit. The Gemini has even less field of view than Mercury. Apollo has possibly as much per man. To get a large field of view in space the first time, we can do it with the vehicle that isn't going to re-enter (lunar module) - basically that's what it amounts to.

Nordberg - I think it's really fantastic that you fellows have seen what you have seen with such limitations. I think it really probably is one of the reasons that people like ourselves are used to just looking at one dial and we stand in the laboratory and read one meter. These fellows are really looking for everything.

Schirra - Well, I think that this is part of what fell out of the criteria that we were selected from, and that is the inquisitive mind.

We don't like to let things go on without knowing at what they are; and you explore them pretty thoroughly, maybe with limited knowledge, but at least you try to get it down. I have been fighting like mad to get this continuous tape recording. This was invaluable to get answers just like Larry and I and Mrs. Cameron went back and traced out some of this like the smog layer. I would have remembered this, but I probably couldn't have told you when I saw it without referring back to this continuous tape. This is something we are not getting.

O'Keefe - It's quite a fascinating thing to listen to these tape recordings; undergoing this is a tremendous experience. You can hear what the person is - I think that is a debt to humanity - that it ought to be done.

Schirra - I've been fighting for it all along. At least, we ought to be able to store for a period of time and then dump it in fast time and then retape.

Dunkelman - And with your flight we actually see the beginning of an interesting turn of events. In the past, people on the ground - I think we had...

Schirra - Sure.

Dunkelman - Would tell the astronaut what to look for - now in your case, when you saw this brownish smog thing - here's a case where you could have said to the ground, "now, you look" now, it seemed bright enough, so if there were any people on the ground -

Schirra - Unfortunately, I'd left my last point of contact which was

the Indian Ocean Ship.

Dunkelman - Yes, but the point is this is the return, what I'm trying to get at -- the moment you saw that which no one saw at the time on the ground is the beginning of a new period which we have to take advantage of on the next flight.

Schirra - Oh, of course.

Dunkelman - Here's the case where an astronaut can tell the ground, "Now look" - "here now", you see.

Schirra - Interestingly enough - it was about that same time when the Indian Ocean ship saw me.

Dunkelman - Oh, oh, now of course they are in the clouds and ...

Gill - Much more interested (in seeing you).

Schirra - I didn't know it at that point though.

Nordberg - That lightning case, though ...

Schirra - Yes, I gave them a weather report and they didn't believe me either. (laughter) They said, "Oh, it's clear here." Well, of course, I had to look back on a very long slant line to see the flare, and this was then covered by clouds, well, then, if this were Woomera, then the cloud structure would go up like this we'll say, well, I was over here, so I really couldn't see Woomera at that time. That's how I satisfied myself I never would even though they had a beautiful clear sky over their station for that first period.

Tennyson - This is not only great for you, it's great for the scientific world.

Schirra - It is.

Tennyson - It's good to have somebody else who isn't constrained to party lines.

Gill - It's a privilege to meet with you, really.

Tennyson - Something that shocks me is that the discussion from Scott Carpenter and your discussion is the picking out of clues from about, heaven knows, how many scientific disciplines from your general experience etc., and integrate them all together and be able to present them; frankly, I just find this very interesting that anybody can do that. The wide range of experience.

Schirra - I think it's the opportunities of so many exposures we've had and we have taken advantage of them, and as an example, we can have an audience with you people anytime we call, and if we have questions and this is true throughout the whole program. I can talk to Von Braun if I'd like to right now. I can talk to a technician that's working on a nut and bolt on Von Braun's booster right now. We have this prerogative which is very great for us. We are not stuck with the disciplines of crossing party lines or anything like this or going up to the ladder and back down again. We go - we just take a straight path to where we want to get information. It is a tremendous opportunity for us, and we try not to abuse it, but we use it liberally really. I might add that anytime you have a question, our phones are always available for this kind of thing. Don't ever think we are incommunicado.

Shoemaker - Good - that's very good, Commander. I'd like to thank you very much.

Schirra - Sure, I was glad to come by.

THE END

President E

he can observe and make judgments that no instrument or animal can accomplish.

As an example, Douglas said that Glenn, on his own initiative, had turned his spacecraft around 180 degrees on his second orbit to see whether the mysterious "fireflies" he had noticed on his first orbit might be paint or other particles from his craft.

The astronaut found that the unknown objects streamed past his window in the same direction as on his first sighting, proving they were independent of the spacecraft.

Scientists here believe the still unknown luminous particles, when further explored, may lead to important new knowledge of space phenomena. No unmanned satellite or observation from earth had detected anything like this before.

Glenn reported they were small, but as he lacked any checkpoint, it could be that the particles were more distant and larger than he thought.

Similarly, scientists are much interested in the luminous haze belt Glenn saw about 7 to 8 degrees above the horizon over the dark part of the earth Tuesday. Soviet cosmonaut Gherman Titov reported seeing about the same thing, but there has been no explanation of it as yet.

These observations, say Mercury officials, are an answer to those who have opposed sending man into space when instruments can make observations better and cheaper.

Astronaut Glenn, himself, believes that the most significant technical result of his flight was to prove the importance of man as a pilot in space travel.

"We have piped man aboard as the pilot of spacecraft," he said in nautical lingo. "Now we can get rid of some of that automatic equipment."

Much of the weight of the Friendship 7 capsule includes duplicating systems put in because it was not known whether man could function in a weightless state.

The fact that man can be an active pilot and not largely a passenger on a spacecraft will have its impact on future Mercury flights and later plans
Apollo s
Glenn,
tried to
terious "fi
held 35-mi
filled with
Force docto
tives showed
ible but they
larged for clos
perts.

In reloading
Douglas said, Gl
grip on a film ca
floated in front
weightless flight.
for it, the tip of h
it and it "sailed a
never could get
again."

The astronaut r
he had no trouble
tablets and a
squeezed from a
Douglas said h

MILK—*From*

No Need For Anti

wards year's end an
again next spring.

If the estimated level
to be those actually
enced, they will still
below the "permissible
els set by Government
cials.

No Marked Strontium Rise

The PHS yesterday also
ported that radioactive stro
tium measurements from Se
tember through Novembe
1961, do not "differ materia
from those found prior to r
sumption of Russian nuclea
weapons tests." Milk sample
from Washington, for exam
ple, averaged seven micro
microcuries per liter during
September and 10 micromicro-
curies during October and No-
vember.

These figures do not vary greatly from those reported for other American cities, with the exception of Port-land, Ore., which showed 3
micromicrocuries per lite
during November. A P
spokesman said the Portl

Director Space Sciences

~~Some~~ Considerations and recommendations of Manned Space Exploration Following the Interview (Feb. 27) with Lt. Col. John H Glenn Jr.

Recommendations

I. Publication Sci Journal - Astronaut Observations

Additional support to Astronauts - instruments -

Follow-on discussions with Glenn and report and evaluation of his observations

Dark adaptation - further experiments

Artificial comets feasibility

Photo electric photometers and two dimension filter - with wave length [illegible] transfer.

NASA Administration

Coordination of scientific experiments

= Direct support of astronauts - scientific team - branch or division

= Committees or subcommittees - Rocket Instrument & Survey Science

Hq - Program chief -

Memo Glenn

-

Some consideration of Manned Scientific Space Exploration

Following the Interview with Col John H Glenn Jr

→ Glenn scientific paper ←

Orion - nebula

→ [illegible]

- discovery - horizon bit - not window

luminous particles - velocity [illegible]

→ [illegible]

"Artificial comets"

~ Recommendation / Support of astronauts -

= Committee - Subcommittee

Danjon - Rach, Minnaert, [illegible], [illegible] -

= Correspondent responsible groups

headquarters -

→ Instrumentation

→

= Paper - by Glenn.

- Followers meeting

= Artificial comets feasibility -

example - experiments

- Conditions described

= pin head - to ~~+~~ 1 cm - -

= observed for 3 1/2 to 4 min - from first light of sun.

= observed on all three (3) orbits

= very luminous - yellow green color (gold bright blue green ≡ white colour)

= 2 to 3 meters separation

= velocity thru the field - 3 to 5 miles/hr. !- - constant rate any ahead

= not water ice phase or crystal from hydrogen gets / plasma - or photochemical →

Paper

① Observation conditions

② Geometrical distribution → shape - structure

③ Velocity estimate - Gases - - Velocity distribution

① Space craft source -
Examination of space craft and booster
(Repeated observations of successive orbits)

② Natural environment - - orbit → eccentric - circular interaction
- controls -
- angles
- satellite measurements

③ Comet theory -
- mechanism - gravity - electrostatic
- implications - plane of deformation

Further experiments
- observations
- controlled releases.
-

- IR

U.V. cameras

- light meters

- Glenn

- draw -

~ ∡ 6° - window 30°

- 10 - 15 min normal dark adaptation

> 27% window cut down

- daytime stars > min adaptation

= Sun not too blinding - could look at it -

Very clear brilliant white light - like arc lights

Sunset

- broad band on atmosphere - 45 to 60° arc -

yellow - orange blue - black -

- sun gone long slivers - at tangent

4 or 5 min

- twin suns - zodiacal lights -

- solar corona.

- Haze layer -

stars dim - then - brights -

band - 6 to 8° above the horizon

- about 2° wide

~ almond buff white - beiges

1/4°/sec - drift rate - ? spitting thrusters

~ no airglow band -

could see lightning!

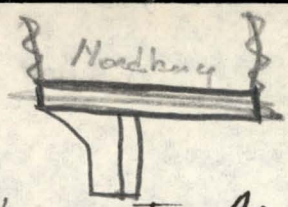
- discontinuities - in twilight arch -

- probably weather build up

? - 15° up - green band - ? ∡ f sun - ~ 6 sec

Woolfest

Mr. Wilford



H_6 - ROX and composition A. and $\frac{1}{2}$ NT - and Al

NO O

Al powder 30% Potassium perchlorate 30% Barium nitrate

50km to 150km

6 or 7 rockets

~ Ed Dyer Dyer Dublin

13 -

~ Web - Lindley NASA →

Editorial ~ board ~ - meet -- June 1

~ Wexler

- all moving in same direction

~ some seemed to flow around

= brilliant in mind so-as [illegible] in black summer night

- very steady light

= yellow green

~ no end to them -- in all directions

- white - past window - piece of cotton

~ all moved at same speed -

~ oblate spheroid

~ no change in intensity

- far fewer - looked turned around

~ could see - about 5 minutes

~ 500' - ?

same number each direction -

density - same.

- looked like - aerodynamic - flow

"*Meteors*" (*A Symposium on Meteor Physics*): *Special Supplement* (*Vol.* 2) *to J. Atmosph. Terr. Phys.* (1955)

Meteor Ionization in the *E*-region

MAURICE DUBIN
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ABSTRACT

The theories of meteoric interaction with the atmosphere have been reviewed to determine the total contribution by meteors to the ionization content of the *E*-region. From Herlofson's theoretical treatment of this interaction, and Watson's distribution of the size and numbers of meteoric particles entering the atmosphere per day, the number of electrons produced at various altitudes in the *E*-region was computed. These computations indicated that most of the ionization at higher altitudes resulted from meteors of large visual magnitude. Since, as Whipple has shown, the ablation process would probably not occur in the case of micrometeorites because of heat loss by radiation, the collision processes for ionization were reviewed; it seems that the ionization process is mainly a function of the relative energy of the collision, and therefore ablation prior to ionization would not be required for small particles. Using the value (of GREENHOW and HAWKINS, 1952) for the efficiency of the ionization process and the recently revised value for the amount of meteoric material entering the atmosphere per day, the rate of production of electrons was found to be 20 electrons/cc sec. From this value and the recombination coefficients in the *E*-region, the equilibrium electron density in the *E*-region was found to be between 2×10^4 and 7×10^4 electrons/cc. It is therefore proposed that the night-time value for the electron density in the *E*-region results from meteoric bombardment, and that sporadic *E* is caused by the same process on the assumption that the distribution of meteoric particles in space is non-isotropic and contains centres of high density. Perhaps, also, the interaction of charged micrometeorites with the earth's magnetic field, may be considered as a mechanism for the production of magnetic storms.

1. INTRODUCTION

METEORS, as commonly known, are extra-terrestrial particles of only a few milligrams, which enter the earth's atmosphere at relatively high velocities. In their interaction with the air, they are vaporized by the heat generated and are responsible for the emission of light and production of ions along the meteor trail. The major portion of the kinetic energy of the meteoric particles is absorbed in the altitude region between 80 and 120 km. It is attempted below to consider whether the integrated effects of this meteoric interaction might contribute to the structure of the *E*-region.

2. THEORY

HERLOFSON (1948) has constructed a model for the interaction of meteoric particles with the atmosphere. It is assumed that in the region of meteoric flash, the mean free path of the molecule is much greater than the radius of the meteor. Under such conditions, the front surface of the meteor is bombarded by single air molecules and the major portion of them is trapped in the metal surface. The kinetic energy relative to the meteor which is given up to the meteor suffices to bring the temperature to that of evaporation. The meteor atoms evaporate off the meteor (ablation) with velocities appropriate to the temperature and the relative velocity of the meteor with respect to the air.

From consideration of the physical interaction of the meteor with the air mass, using the differential form of the conservation of energy and momentum, HERLOFSON determined the equation for the rate of evaporation at any point along the trail.

$$n = \tfrac{9}{4} n_{\max} (p/p_{\max}) [1 - \tfrac{1}{3}(p/p_{\max})]^2 \qquad (1)$$

where $n_{\max} = 7 \times 10^{23} r_\infty{}^3$ = the maximum rate of evaporation.
p = the pressure at any point along the trail.
$p_{\max} = 4 \times 10^{-2} r_\infty$ = pressure along the trail where $n_{\max}$ occurs.
r_∞ = the initial radius of the meteoric particle.

Since the velocity distribution of meteors is over the range from 10 to 70 km/sec, for the purpose of computation an average velocity of 40 km/sec was used. p_{max} and n_{max} were determined accordingly.

From equation (1) and WATSON'S (1941) estimate for the number and size distribution of meteors entering the earth's atmosphere Table I was computed. The computation has been made for three altitudes, 85 km, 100 km, and 115 km, using the following rocket pressures:

Altitude (km)	Pressure (mm of Hg)	Number density of air molecules (cm^{-3})
85	4×10^{-3}	10^{14}
100	4×10^{-4}	10^{13}
115	4×10^{-5}	10^{12}

Thus equation (1) becomes

$$n = \frac{9}{4} \times \frac{7 \times 10^{23}}{4 \times 10^{-2}} p r_\infty^2 \left(1 - \frac{1}{3} \frac{p}{4 \times 10^{-2} r_\infty}\right)^2$$

$$n_{85} = 1.6 \times 10^{23} r_\infty^2 \left(1 - \frac{1}{30 r_\infty}\right)^2$$

$$n_{100} = 1.6 \times 10^{22} r_\infty^2 \left(1 - \frac{1}{3 \times 10^2 r_\infty}\right)^2$$

$$n_{115} = 1.6 \times 10^{21} r_\infty^2 \left(1 - \frac{1}{3 \times 10^3 r_\infty}\right)^2.$$

The number of electrons per cm of path becomes, from HERLOFSON (1948),

$$n_e \text{ cm}^{-1} = \frac{n \times 10^{-2}}{v} = \frac{n \times 10^{-8}}{4}.$$

From Table I it is evident that the number of electrons for a shell of 1 cm thickness over the surface of the earth, resulting from meteors, is 10^{20} electrons per day at 85 km produced mainly from meteors of visual magnitudes 1 to 4, about 10^{20} electrons per day at 100 km with the major contribution for visual magnitudes 6 to 15, and again about 10^{20} electrons per day at 115 km from mag. 7 to 20. The number of electrons produced per cm of path per cm^2 per sec at these three altitudes is thus $10^{20}/(4.4 \times 10^{23}) = 2 \times 10^{-4}$ electrons per cm^3 per second.

Now according to HERLOFSON, the kinetic energy of a typical meteor is divided in the ratio $10^4 : 10^2 : 1$ for the production of heat, light, and ionization, respectively. These values were used in the computation of Table I. However, from

Table I. Calculation of the number of electrons produced per cm of path per meteor and per twenty-four hours as a function of visual magnitude.
(number in upper right is power of 10)

Visual magnitude	Observed No. of meteors	True No.	Mass, g	Radius cm	Height = 85 km			Height = 100 km			Height = 115 km		
					No. of atoms evap. cm^{-1}	No. of electrons n_e cm^{-1}	Total No. of electrons n_e cm^{-1}	No. of atoms cm^{-1}	n_e cm^{-1}	Total n_e cm^{-1}	No. of atoms per cm	n_e cm^{-1}	Total n_e cm^{-1}
−3	$2{\cdot}8^{+4}$	$2{\cdot}8^{+4}$	4	$6{\cdot}5^{-1}$	$6{\cdot}0^{22}$	$1{\cdot}5^{14}$	$4{\cdot}2^{18}$	$6{\cdot}7^{21}$	$1{\cdot}68^{13}$	$4{\cdot}7^{17}$	$6{\cdot}7^{20}$	$1{\cdot}68^{12}$	$4{\cdot}7^{16}$
−2	$7{\cdot}1^{+4}$	$7{\cdot}1^{+4}$	1·6	$4{\cdot}83^{-1}$	$3{\cdot}0^{22}$	$7{\cdot}5^{13}$	$5{\cdot}32^{18}$	$3{\cdot}7^{21}$	$9{\cdot}25^{12}$	$6{\cdot}56^{17}$	$3{\cdot}7^{20}$	$9{\cdot}2^{11}$	$6{\cdot}6^{16}$
−1	$1{\cdot}8^{+5}$	$1{\cdot}8^{+5}$	$6{\cdot}3^{-1}$	$3{\cdot}54^{-1}$	$1{\cdot}72^{22}$	$4{\cdot}3^{13}$	$7{\cdot}73^{18}$	$2{\cdot}1^{21}$	$5{\cdot}25^{12}$	$9{\cdot}45^{17}$	$2{\cdot}1^{20}$	$5{\cdot}3^{11}$	$9{\cdot}5^{16}$
0	$4{\cdot}5^{+5}$	$4{\cdot}5^{+5}$	$2{\cdot}5^{-1}$	$2{\cdot}60^{-1}$	$8{\cdot}3^{21}$	$2{\cdot}1^{13}$	$9{\cdot}5^{18}$	$1{\cdot}1^{21}$	$2{\cdot}75^{12}$	$1{\cdot}25^{18}$	$1{\cdot}1^{20}$	$2{\cdot}8^{11}$	$1{\cdot}25^{17}$
1	$1{\cdot}1^{+6}$	$1{\cdot}1^{+6}$	$1{\cdot}0^{-1}$	$1{\cdot}92^{-1}$	$4{\cdot}0^{21}$	$1{\cdot}0^{13}$	$1{\cdot}1^{19}$	$5{\cdot}6^{20}$	$1{\cdot}4^{12}$	$1{\cdot}54^{18}$	$5{\cdot}8^{19}$	$1{\cdot}45^{11}$	$1{\cdot}60^{17}$
2	$2{\cdot}8^{+6}$	$2{\cdot}8^{6}$	$4{\cdot}0^{-2}$	$1{\cdot}41^{-1}$	$1{\cdot}86^{21}$	$4{\cdot}65^{12}$	$1{\cdot}30^{19}$	$3{\cdot}1^{20}$	$7{\cdot}75^{11}$	$2{\cdot}17^{18}$	$3{\cdot}2^{19}$	$8{\cdot}0^{10}$	$2{\cdot}24^{17}$
3	$6{\cdot}4^{+6}$	$7{\cdot}1^{6}$	$1{\cdot}6^{-2}$	$1{\cdot}04^{-1}$	$8{\cdot}0^{20}$	$2{\cdot}0^{12}$	$1{\cdot}42^{19}$	$1{\cdot}6^{20}$	$4{\cdot}0^{11}$	$2{\cdot}84^{18}$	$1{\cdot}7^{19}$	$4{\cdot}3^{10}$	$3{\cdot}0^{17}$
4	$9{\cdot}0^{+6}$	$1{\cdot}8^{7}$	$6{\cdot}3^{-3}$	$7{\cdot}6^{-2}$	$2{\cdot}9^{20}$	$7{\cdot}25^{11}$	$1{\cdot}30^{19}$	$8{\cdot}5^{19}$	$2{\cdot}13^{11}$	$3{\cdot}84^{18}$	$9{\cdot}2^{18}$	$2{\cdot}3^{10}$	$4{\cdot}1^{17}$
5	$3{\cdot}6^{+6}$	$4{\cdot}5^{7}$	$2{\cdot}5^{-3}$	$5{\cdot}6^{-2}$	$8{\cdot}0^{19}$	$2{\cdot}0^{11}$	$9{\cdot}0^{18}$	$4{\cdot}4^{19}$	$1{\cdot}1^{11}$	$4{\cdot}95^{18}$	$5{\cdot}0^{18}$	$1{\cdot}3^{10}$	$5{\cdot}6^{17}$
6		$1{\cdot}1^{8}$	$1{\cdot}0^{-3}$	$4{\cdot}12^{-2}$	$9{\cdot}17^{18}$	$2{\cdot}43^{10}$	$2{\cdot}7^{18}$	$2{\cdot}3^{19}$	$5{\cdot}75^{10}$	$6{\cdot}32^{18}$	$2{\cdot}7^{18}$	$6{\cdot}8^{9}$	$7{\cdot}4^{17}$
7		$2{\cdot}8^{8}$	$4{\cdot}0^{-4}$	$3{\cdot}03^{-2}$	$1{\cdot}46^{18}$	$3{\cdot}65^{9}$	$1{\cdot}02^{18}$	$1{\cdot}15^{19}$	$2{\cdot}88^{10}$	$8{\cdot}05^{18}$	$1{\cdot}46^{18}$	$3{\cdot}7^{9}$	$1{\cdot}02^{18}$
8		$7{\cdot}1^{8}$	$1{\cdot}6^{-4}$	$2{\cdot}24^{-2}$				$5{\cdot}75^{18}$	$1{\cdot}44^{10}$	$1{\cdot}02^{19}$	$7{\cdot}8^{17}$	$1{\cdot}96^{9}$	$1{\cdot}39^{18}$
9		$1{\cdot}8^{9}$	$6{\cdot}3^{-5}$	$1{\cdot}65^{-2}$				$2{\cdot}82^{18}$	$7{\cdot}1^{9}$	$1{\cdot}27^{19}$	$4{\cdot}2^{17}$	$1{\cdot}06^{9}$	$1{\cdot}91^{18}$
10		$4{\cdot}5^{9}$	$2{\cdot}5^{-5}$	$1{\cdot}21^{-2}$				$1{\cdot}20^{18}$	$3{\cdot}0^{9}$	$1{\cdot}35^{19}$	$2{\cdot}16^{17}$	$5{\cdot}4^{8}$	$2{\cdot}4^{18}$
15		$4{\cdot}5^{11}$	$2{\cdot}5^{-7}$	$2{\cdot}6^{-3}$				$(1{\cdot}08^{16})$	$2{\cdot}7^{7}$	$1{\cdot}21^{19}$	$8{\cdot}2^{15}$	$2{\cdot}05^{7}$	$9{\cdot}2^{18}$
20		$4{\cdot}5^{13}$	$2{\cdot}5^{-9}$	$6{\cdot}0^{-4}$							$1{\cdot}16^{14}$	$2{\cdot}9^{5}$	$1{\cdot}30^{19}$
25		$4{\cdot}5^{15}$	$2{\cdot}5^{-11}$	$1{\cdot}21^{-4}$									
30		$4{\cdot}5^{17}$	$2{\cdot}5^{-13}$	$2{\cdot}6^{-5}$									

consideration of long-duration meteor echoes it has been suggested that the electron density in the trail is greater than the critical density for the radio wavelengths employed in probing meteors, and has led to a revision of the Herlofson ratios for the production of heat, light, and ionization. GREENHOW and HAWKINS (1952) thereby found that a meteor of visual magnitude +6 would produce approximately 10^{12} electrons per centimetre of path. This is one hundred times greater than HERLOFSON'S estimates, and leads to a discrepancy of roughly five stellar magnitudes between his theoretical estimate and the experimental determination of electron-line density in meteor trails. GREENHOW and HAWKINS conclude that meteors produce more ionization than was originally estimated. Instead of the kinetic energy of the meteor being divided between heat, light, and ionization in the ratio $10^4 : 10^2 : 1$, the ratios are probably $10^4 : 10^2 : 10$ for bright meteors, and $10^4 : 10 : 10$ for faint meteors. These revised estimates imply that the visual magnitudes corresponding to an echo of given characteristics is about five magnitudes fainter than given by HERLOFSON. This means that the majority of echoes of short duration must arise from meteors which are below the limits of naked-eye visibility, and conversely, that all visible meteors must produce radio echoes of long duration—a well-known observational fact.

A further consideration in the model of HERLOFSON is the fact that unmelted meteorites have been found on the surface of the earth. WHIPPLE (1950, 1951) has shown that the micrometeorite, if below a certain size, can dissipate the energy gained sufficiently rapidly to permit these particles to be stopped by the atmosphere without melting. Recalling that the Herlofson model required that ablation of the meteorite was the initial step in the production of light and ionization, this point warrants some discussion. GREENHOW and HAWKINS (1952) have indicated that for radio meteors the amount of light produced is correspondingly reduced for small meteoric particles but the relative ionization is not reduced, but rather is generally larger than indicated by HERLOFSON'S treatment.

It seems worthwhile to review briefly the physical process involved in the interaction of a micrometeorite with the atmosphere. Since it is not believed that ablation results for these very small particles, one might question whether or not the ionization efficiency would become correspondingly poorer. The physical problem is one of considering a collision of the micrometeorite with a molecule or atom of air, with the relative energy of collision in the range from 10 to 800 eV. The mean free path of the air is much greater than the diameter of the micrometeorite, and thus the problem may be treated by kinetic theory rather than fluid dynamics.

There are several processes which might occur: (1) An elastic collision of a molecule of air with the micrometeorite would yield a molecule with a velocity capable of ionizing. (2) An inelastic collision of a molecule of air with the micrometeorites such that the air molecule enters the surface of the micrometeorite, and thereby heats the micrometeorite and also forms a "monolayer" on the surface; such molecules if not chemically bonded to the surface might very easily evaporate off the surface with the velocity high enough for ionization. (3) Secondary ionization from collisions with a surface. (4) Attachment to oxygen by the collision and the eventual addition of a free electron to the atmosphere; and (5) sputtering of

the micrometeorite and the subsequent ionization by the freed particle. Experimental information on collisions of neutral particles and the resulting excitation and ionization is very limited. Much of the available information is contained in MASSEY and BURHOP (1952).

Although the ionization efficiency is much greater for electrons than for heavy ions, as long as the ion energy is greater than the threshold value for ionization, the possibility of ionization exists. For example. a recent technique for obtaining velocities for neutral particles near the range of meteor velocities is the shock-tube method of RESLER *et al.* (1952). It was found that the extent of ionization as a function of Mach number was rather large. In the case of argon at Mach 18, argon at 1 cm of Hg pressure was 50 per cent ionized. Mach 18 corresponds to a linear velocity of $18 \times 0{\cdot}350 = 6$ km/sec, somewhat less than meteor velocities. For this low velocity there also was a highly luminous region associated with the shock fronts in both argon and air.

BERRY *et al.* (1942) investigated the ionization of gases by collisions of their own accelerated molecules. They found that the onset energies observed for such ionization were roughly only three times the ionization potentials of the atoms. They also concluded that in the range of speeds for argon between 48 eV to 1,000 eV, relatively little change had occurred in the kinetic energy delivered to the newly formed argon ion, and therefore it seemed unlikely that the mechanism of ionization was one involving a transfer of kinetic energy. Also at energies of about 2,000 eV the cross-section for ionization of argon was greater than for N_2 by only a factor of 2. In fact the arrangement of the cross-sections for ionization in decreasing order was found to be A, N_2, H_2, and He.

An estimate of the order of magnitude may be determined (for a few of the reactions) from MASSEY and BURHOP. Although most experiments have been made with positive ions, it seems that the cross-section for ionization in the case of neutral atoms is at least the same order, but usually somewhat higher.

The secondary emission coefficient for surfaces, γ, is the number of ejected electrons per incident positive ion. Some observers have found a higher value of γ for surfaces which oxidize readily, implying that higher values arise from the oxide layer. PAETOW and WALCHER (1938) reason that since the electron emission cannot depend much on the work function of the adsorbed atoms, in the case of a monolayer of oxygen on caesium, it would follow that the extra electron emission came from the absorbed layer itself. The value of γ for the low-energy range in the case of micrometeorites and based on positive ion bombardment would probably be in the range from 0·02 to 0·5. Allowing for an energy absorption of 10 eV for a secondary electron, these coefficients are in themselves sufficient to give a ratio of kinetic energy absorbed in ionization for 200 eV of better than $10^3 : 1$.

Negative ions have been found to result from the impact of positive ions on surfaces. ARNOT and MILLIGAN (1936) have estimated that for incident Hg^+ ions of about 200 eV energy, about 10^{-3} Hg^- ions were formed per incident ion. For neutral oxygen atoms and molecules which also form negative ions, this ratio could very well be higher. Positive ions incident on surfaces may be reflected without neutralization, although it is generally felt that an ion on striking a wall becomes neutralized. For rare gas ions incident on nickel, the reflection coefficient

found by HEALEA and HOUTERMANS (1940) was in the range from 0·2 to 0·05 for ions of He, Ne, and A at about 400 eV.

The impact of ions on a solid surface results also in a process known as sputtering, wherein atoms or clusters of atoms are ejected from the surface as a result of impact. The threshold for sputtering is of the order of 40 eV, and most values given for rate of sputtering lie between 1 and 10 gm/amp hour. For incident ions at 200 eV the sputtering rate would probably fall to one-third this range of values. For a surface containing atoms of mass number 60, one gram per ampere hour is equivalent to approximately 0·5 sputtered atoms per incident ion. Thus the sputtering rate for metallic meteorites might be of the order of one atom per incident air particle and possibly higher for stony meteorites.

Basically, for all these processes the important parameter for ionization is the relative velocity. The relative amount of energy absorbed by ionization should not be different, whether or not ablation of the meteoric particle occurs. Because of the long-mean-face path of air compared to the size of the meteoric particle, the air particles must act independently of each other. Effectively the cross-section for ionization might increase during evaporation, but this is equivalent to increasing the air density to allow for a larger number of collisions. Indeed, one may, as a gross estimate, expect that on the average a fixed percentage of the kinetic energy absorbed by the air is transmitted into ionization with an efficiency given by GREENHOW and HAWKINS' correction of HERLOFSON'S treatment.

Recently WHIPPLE (1952) has investigated the amount of meteoric material entering the earth's atmosphere. From experiments of BURNIGHT, and BOHN and NADIG, using rockets; CROZIER and SEELY on air pollution; VAN DE HULST and ALLEN by observations of zodiacal light and eclipses, and PETTERSSON and ROTSCHI from observation of deep-sea sediments containing nickel: WHIPPLE noted that data from these methods generally agree as to order of magnitude of the amount of material falling into the earth's atmosphere. From this, the frequency of small meteoric bodies encountering the earth's atmosphere should exceed the older estimates based on meteors and meteorites (WATSON'S) by a factor of possibly 10^4. The result is perhaps 10^3 tons or more per day on the entire earth.

Earlier the value for the number of electrons formed per cc/sec was found to be 2×10^{-4} electrons per cc/sec, based on WATSON'S estimates and HERLOFSON'S theory. Since GREENHOW has indicated that HERLOFSON'S value should be increased by a factor between 10^2 and 10, and the number of micrometeorites should be increased by a factor of 10^4 to 10^3, the rate of production of electrons should be multiplied by a factor of about 10^5, giving an average production rate of electrons of twenty electrons per cc.

Having determined roughly the rate of production of electrons, the rate of disappearance of electrons must be considered in order to calculate the equilibrium electron density. The rate of loss of electrons along the meteor trail is given by

$$\frac{\partial n}{\partial t} = D\nabla^2 n - \alpha n^2 - \gamma n n_0$$

Where D is the diffusion coefficient, α the recombination coefficient, γ is the coefficient of attachment, n_0 is the neutral atomic or molecular density, and n is

now the electron density. For small particles, where the number of electrons formed per centimetre of path is small, the diffusion term is predominant, and the train quickly decreases to the equilibrium electron density, which is thus given by

$$\alpha n^2 = \text{rate of production of electrons.}$$

The effective recombination coefficient for the E-region is $\alpha(O_2) \simeq 5 \cdot 10^{-8}$ $cm^3\ sec^{-1}$, when O_2 is present, and $\alpha(O) \simeq 4 \times 10^{-9}$ $cm^3\ sec^{-1}$ if oxygen has been dissociated. Thus n is approximately equal to $7 \cdot 10^4$ and $2 \cdot 10^4$ in the upper and lower E-region, respectively.

3. Conclusions

The above is applicable to three effects in the E-layers. First, the diurnal variation of the E-layer is found to agree fairly well with the $(\cos \chi)^{\frac{1}{2}}$ law for the variation of the simple Chapman region (χ is the zenith angle of the sun). The variation is found to be almost symmetrical with reference to the maximum at noon (Mitra, 1952). However, with the accepted value of the recombination coefficient, the E-layer ionization at night should fall to a very low value. The residual ionization density as observed is much greater than it should be. It is therefore suggested that this night-time value results from the bombardment of micrometeorites.

Secondly, measurements of effective electron density obtained by rockets (Lien *et al.*, 1953) indicated that a bifurcation, or two maxima, in electron density were present in the E-region. It is suggested that one maximum results from solar radiation, the other from micrometeoric bombardment.

And finally, it is proposed that the sporadic E-clouds of ionization result from micrometeorites. Although some correlation with meteor showers is found, the major portion of the ionization results from micrometeorites with a fine structure undetectable by radio probing. The cloud-like structure of the E-layer very possibly results from clouds of micrometeorites. The amount of micrometeorites, the penetration depth, the ionization efficiency, and the distribution of the micrometeorites are all consistent with the conditions required for such an explanation. Granted the laboratory evidence for the ionization process is not adequate, but the general physical reasoning based on ionization density measurements by radio methods of lower visual magnitude meteorites leads to an order of magnitude that seems very promising.

In conclusion, it may be possible also to relate the meteoric bombardment of the upper atmosphere to the high-latitude magnetic storms and aurorae. For this process it is necessary that sufficient photoelectric effect from solar ultraviolet radiation be present to charge the micrometeorites and thereby allow some control by the earth's magnetic field. This investigation will be described elsewhere.

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