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It is an honor and a pleasure for me to be given the privilege of sitting up here all by myself on the platform and supposedly being the chairman of this session from which we are going to have so much dynamic information. I suspect that this was done so that I would not talk too much and I am going to try to restrain myself. As I sit here looking at all the attendees, I find that I have known a large part of this group for many years. I am sort of forced to think about new techniques, not in adaptive control systems, but in the methods of getting things done. We start out and get thinking people in on the job before it is really well defined. I can't compete with General Davis' stories, but I would like to illustrate my point by a little story that I think is very pertinent.

The story deals with a contractor that had a beautiful wife and a son about five or six years old. The contractor told his son that he was about to have a little sister or a little brother, and the little sister or brother would be along sometime after the first of the year. The boy said, "Gee, wouldn't it be nice if we had it here for Christmas?" His father told him, "Well, I'm afraid this is a little hard to do. I don't think we can do this". So the son said: "Well, if you are building a building and want to do it a little faster you put about a hundred more men on the job, why don't you do the same thing here?"

Actually, we are now doing research and development by this procedure. It used to be that a few people, or a few organizations, worked on a new development until the idea was pretty well jelled. When something significant came out a lot of other people then went on to make the equipment or do whatever was required. Now we don't wait for the impetus to be born, we actually get people in on the deal when the conception is nothing more than a probability. As far as I know this is a new technique in the history of the world. I don't believe we ever did it much in this country, the Germans didn't do it very much, and whether the Russians do it or not I don't know. It would be interesting to find out.

I am going to take a few minutes here and try to make a few definitions that perhaps will give a little meaning to the overall picture before we get involved in mathematics. Later on you can argue with me if you want to, but I would like to define flight control as the process of maintaining the vehicle involved within a range of attitudes and motions that provide safe operation, and permit the effective utilization of guidance. Guidance is the process of indicating deviations of the actual vehicle path from the desired path and generating a correction command signal for the flight control system. In other words, guidance stems from subjectory type of things. We are interested primarily in what the center of gravity is doing and not concerned about the attitude of the vehicle. The flight control system merely enables you to realize the guidance correction that the guidance system has found to be necessary.

To sketch in the background of this thing, as I see it, flight control is a very, very old art. It goes all the way back to the days of the gliders. Both flight control and guidance in those gliders were provided by the human that was being lifted along with the vehicle. The man looking out sensed the deviation from the path that he wanted and he translated those deviations in the motions of his own body so that he provided both guidance and flight control. The eyes were the sensing media and the pilot's body was an effective medium for realizing flight control. This system got into a lot of trouble because they thought the way to control the glider was to make it very stable and, in effect, have the same conditions that you have in a ship. The ship sort of rides on the waves and you turn a rudder to steer it. The trouble, of course, with these stable vehicles were that they were so stable that the human being couldn't do what he wanted to do. This didn't produce very high class flights, and led to catastrophic results before they got into bad air conditions.

The Wright Brothers have been given credit for a lot of things and most of these are things that I think they didn't do. What they did do was to provide a machine which, in itself, was unstable, but when you put the man in it to provide the sensing, the judgment for developing guidance commands, and the ability to translate those commands into motions for control purposes, the combination resulted in satisfactory flight stability. By making the vehicle itself unstable, but controllable, and putting the man in the loop the Wright brothers came out with an overall result that was a pretty good flying machine for those days. As a matter of fact, the pattern that they had established is the one that is very largely used today.

The replacement of the man and his sensing by an instrument started in 1918 with the gyroscopic turning gear and continued with the Guggenheim competition. The Guggenheim developments led Doolittle and Brown to the blind flying business where more of man's senses were replaced by gyros; however, the man continued to generate guidance and do a considerable part of the flight control. Autopilots that have replaced more of man's functions came along in the early 30's. I remember seeing the Sperry Gyroscope Company's first autopilot. They made three of them and, if I remember correctly, they had a terrible time selling them. Nobody was interested in them. Whiley Post took one of them and he flew around the world and you know what happened after that.

Developments have followed in this field for a matter of twenty years or so until we have the all maneuver autopilot today. Flight control systems of today are a far cry from those first few autopilots. Now the flight control systems are adapted to receive guidance commands either from radio or radar, or from inertial systems carried within the vehicles. The system that provides guidance is not identical with the system that provides flight control.

I would like to make a couple of remarks regarding adaptive control systems and I would like to define what I call optimalizing control systems. Optimalizing control systems are exactly what the word says. I use the word " optimal" instead of " optimize" because optimize in the dictionary refers to a human type that is always looking too far in the optimistic direction. These systems replace the human function of refining performance as it has been used in many, many systems. For example, if you are conducting a test and you want to find out what fuel mixture ratio gives you the best power, you fix the mixture ratio and you look at the scale beam on the dynamometer. You then change the mixture control and if the scale beam goes up you change it a little bit more in the same direction. Some time you will come to a point where changing the mixture ratio in the same direction causes the dynamometer beam to go down. In this case you reverse the direction of your mixture control adjustment. You do the same thing if you are trying to get the maximum economy out of flying an airplane. You check how many gallons you have used per hour with a certain mixture ratio and then you try again. This is the basic philosophy of the optimalizing systems and it seems to me that they are adaptive systems. A paper " optimalizing control" was written by Dr. Lee L. Lanning and myself in 1950. It was presented at an ASME meeting in San Francisco in 1950 and resulted in an ASME transaction paper in 1951.

The idea of an adaptive system was first used in anti-aircraft fire control systems in 1939, based on the idea that if you had a target at long range you automatically adjusted the parameters of your system so that it gave you a smooth refined solution. If the range became shorter then you made the system faster but the solution became less accurate. When you started out to get a solution in the aircraft fire control business you deliberately changed the parameters of the system so that you would get a fast solution in the shortest possible time. If the target started to maneuver, you in effect took a reading of the answer that came out and adjusted the parameters of the system in such a fashion that you end up with the best results. As I see it, this is the philosophy used to measure the performance. For the given setting of the target you are going to try to optimalize you keep track of what happens in performance, and you make a change, and you see whether the results are better or worse than you had. If they are better, you do one thing and if they are worse, you do another. You are, in fact, using a sampling closed route method of adjusting the system.

This is not exactly what Captain Rath has said, but I think it has the same general idea. I have already talked too much and I thank you gentlemen for your attention.