do not produce transitions but greatly reduce the average velocity in a particular direction, and hence the broadening of a line due to the Doppler effect. An optical means of detecting transitions between the hyperfine levels has given an increased sensitivity and a line 40 c/sec wide (in 9,192 Mc/sec) has been observed. The actual frequency is influenced by the buffer gas, however, and the new techniques do not at present provide a definitive standard.

5. *Conclusions.* It is concluded from this review that the Maser-type ammonia standard can be used to define frequency in terms of a spectral line with an accuracy of ± 1 part in 10^8 and that the reproducibility of a carefully defined Maser is considerably better.

Existing cesium standards can be used to define frequency in terms of a spectral line with an accuracy of ± 2 parts in 10^{10} and the results have been integrated throughout a time interval of three years for the purpose of comparing atomic and astronomical times.

There are goods reasons for believing that the accuracy of the atomic beam-type of cesium standard can be increased by at least ten times and that experiments with new techniques such as optical pumping, and the use of buffer gases will lead to simpler forms of standard.

DISCUSSION

Dr. STOYKO commented that even though the atomic standard is not a clock, it can still be used as a time-keeper through the intermediary of quartz clocks. It has been possible, through the kindness of Dr. Decaux, to use Atomichron No. 107 at the National Laboratory of Radioelectricity in Bagneux to interpolate from the atomic time at the Time Service of the Observatory of Paris and the International Bureau of Time. This atomic standard is compared each day with three quartz clocks which, in turn, are compared with the Time Service at the Observatory of Paris. The integration of frequency of the atomic standard in conjunction with these three quartz clocks permits control of the precision of time maintenance by this method. Since March 1958 this method has been used for the direct interpolation of the correction of the main clock according to the atomic observations of the Observatory of Paris. Since the conventional frequency of the atomic standard does not correspond to the exact second with the provisional Uniform Universal Time (UT2) which is the basis of time services, the correction of the atomic clock must be represented as calculated by a linear function which is of a sufficient precision for an interval of the order of two months.

Prof. MIKHAILOV, the Chairman, asked how long a cesium standard would run.

Dr. ESSEN reported that in the United Kingdom it has been arranged to use the standard which controls the standard frequency transmissions for generating the signals for the time service of the Royal Greenwich Observatory. If the frequency remains as at present based on a value of 9,192,631,830 c/sec for the cesium resonances step adjustments of about one per month would be made to the signals to keep them reasonably close to UT2. If the frequency were changed to 9,192,631,770 c/sec, the value in terms of the second of ephemeris time still more frequent adjustments would be required. It is therefore proposed to operate the service in the following way:

The frequency of 9,192,631,770 c/sec will be used as the standard but the service will operate with an error of about $+160$ parts in 10^{10} so as to bring the frequency and time pulses in close accord with the time scale of UT2. Corrections published by the Royal Greenwich Observatory will give the errors from UT2. Corrections published by the National Physical Laboratory will give the errors from the cesium frequency of 9,192,631,770 c/sec to $+1$ part in 10^{10}. This will also be the error from ephemeris time with the lower precision of ± 20 parts in 10^{10}. All possible time and frequency information will thus be given by the service.

Dr. MARKOWITZ commented that the operation of a cesium clock does not require that the cesium beam itself shall be in operation continuously. The cesium clock at the Naval Research Laboratory, Washington, D. C., consists of a cesium beam frequency standard which is operated in conjunction with a quartz-crystal clock of high precision which indicates time. The quartz-crystal clock is operated continuously, and is adjusted in frequency daily to that of the cesium standard. It is not necessary, therefore, to operate the cesium beam continuously, and in fact, the beam itself may be changed.

(*End of Symposium*)