

precipitation of this compound during service through the action of "the peculiar combination of forces existent in propeller blades." It is felt that attention should be called to certain factors which must be considered in evaluating Drs. Clark and Smith's observations.

Commercial heat treated forgings of 25ST alloy normally contain excess undissolved CuAl_2 which can be readily identified microscopically before as well as after being subjected to service conditions. Obviously this undissolved CuAl_2 will give rise to diffraction lines in x-ray patterns from such material. The amount of undissolved CuAl_2 will vary with the copper content of the alloy, with the period of time and temperature of heat treatment and with the total reduction in sectional area from ingot to finished forging. The presence of CuAl_2 lines in diffraction patterns from 25ST alloy propeller blades cannot, therefore, be accepted as evidence of precipitation brought about by the service conditions.

The experience in these laboratories with both microscopic and x-ray diffraction methods of examining precipitated phases indicates the former to be somewhat the more sensitive in detecting the initial stages of precipitation while the diffraction method, when sufficient precipitated phase is present, gives the most satisfactory means of establishing the identity of the phase. In the present investigation the microscopic method would seem especially applicable inasmuch as it is capable of differentiating unquestionably between precipitated and undissolved CuAl_2 . Careful microscopic examination in these laboratories of used propeller blades as well as numerous fatigue test specimens indicate no visible structural changes as a result of extended periods of service or large numbers of stress reversals regardless of whether or not the stress was great enough to cause ultimate failure.

Diffraction lines attributable to precipitation of CuAl_2 from supersaturated solid solutions of copper in aluminum have been noted only after aging treatments such that the mechanical properties have been decidedly affected. It is to be expected that if service conditions are such as to bring about precipitation of CuAl_2 identifiable by x-ray diffraction means, the mechanical properties should show the effect of this precipitation as they do when precipitation is brought about to a similar extent at elevated temperatures. Such, however, has been found not to be the case. Determinations on a number of blades which have been in service for long periods of time indicate no change in mechanical properties at all comparable with the changes brought about by precipitation at such elevated temperatures as to render CuAl_2 visible by diffraction methods. It is recognized, of course, that quantitatively the effects might differ appreciably, depending on the manner of bringing about precipitation; qualitatively, however, the effects should be the same.

A method of inspection capable of detecting and following progressive deterioration of materials is exceedingly to be desired. It is conceivable that the progressive rejection of CuAl_2 by the supersaturated aluminum solid solution under stress, if it occurred, might form the basis of a means of following progressive changes in mechanical properties. It must, however, first be undeniably demonstrated that such precipitation does take place under the action of stress alone. Also the relationship between such effects and the various mechanical properties must be established.

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May 9, 1933.

The Spectrum of MgF

Two band systems are known¹ for this molecule, the heads of the 0,0 bands occurring at $\lambda 3594$ and $\lambda 2689$. According to Jevons, the first of these represents the ${}^2\Pi$, ${}^2\Sigma$ resonance system analogous to that known for the other alkaline earth fluorides. The second, he has suggested, may be a ${}^2\Pi$, ${}^2\Pi$ transition, having no state in common with the first system. Observations on these systems under high dispersion have been made entirely with the emission spectrum from the arc. In absorption, under low dispersion, the spectrum has been studied by Walters and Barratt,² who list a large number of absorption bands between $\lambda 3659$ and $\lambda 3261$. The strongest of these bear no relation to the $\lambda 3594$ system known in emission, either in position or direction of degradation. This discrepancy has been commented on by Johnson.³

We have now obtained spectrograms in the first and second orders of the 21-foot grating showing the absorption of MgF vapor contained in a steel tube 80 cm long heated to 1150°C . The continuous spectrum from a hydrogen discharge tube was used. These plates show, besides a few atomic absorption lines, three band systems, two of which

are those mentioned above. The third consists of a single sequence of unusual structure, with heads at $\lambda\lambda 2276.72$ (3) 2275.86 (5) 2275.29 (6) 2274.93 (10), degraded to shorter wave-lengths. Obviously the latter system cannot be definitely attributed to MgF without further study, but the fact the only other bands observed are due to MgF renders this assignment probable. We conclude that the measurements of Walters and Barratt represent chiefly bands or lines of extraneous origin.

Since the system at $\lambda 2689$ comes out strongly in absorption, its lower state must be the ${}^2\Sigma$ normal state. Hence it appears certain that this is the analogue of the ${}^2\Sigma$, ${}^2\Sigma$ system known for CaF, SrF and BaF.⁴ The spin doubling must be too small to produce a resolvable doubling of the heads.

¹ W. Jevons, Proc. Roy. Soc. **A122**, 223 (1929).

² O. H. Walters and S. Barratt, Proc. Roy. Soc. **A118**, 134 (1928).

³ R. C. Johnson, Proc. Roy. Soc. **A122**, 199 (1929).

⁴ F. A. Jenkins and A. Harvey, Phys. Rev. **39**, 929 (1932).

Some interesting modifications of the intensity distribution in the bands appear when the absorption spectrum is compared with the arc spectrum. In the $\lambda 2689$ system, a distinct minimum of absorption is observed at $\lambda 2688.38$, in the 0,0 band, which probably represents the band origin. The partially resolved rotational structure is simple, and of the type expected for a ${}^2\Sigma, {}^2\Sigma$ band. In the ${}^2\Pi, {}^2\Sigma$ system at $\lambda 3594$, each band has three heads, and in absorption the successive bands of a sequence fall off in intensity more rapidly with increasing ν than in emission. Also, the third head ($\lambda 3588.224$ in the 0,0 band) is greatly strengthened in absorption relative to the first two ($\lambda 3592.843, 3594.243$). This is consistent with the interpretation of the three heads as belonging to the P_1, P_2 and Q_2 branches, in order of increasing frequency. This is analogous to the case of the BeF bands⁵ except for the direction of degradation. The lower temperature conditions in absorption favor the Q_2 branch, which occurs at a low rotational quantum number. With this structure, it is evident why previous estimates of the electronic doublet separation in the ${}^2\Pi$ state have disagreed,³ since they were deduced from measurements of the heads only. The 0,0 band shows in absorption a minimum at $\lambda 3592.29$, which can be interpreted as the origin of the low-frequency component. The best estimate of the doublet separation we can give at present is the separation of this minimum from the Q_2 head, giving

$A = -31.6 \text{ cm}^{-1}$. It is hoped to obtain more quantitative results, utilizing the partially resolved rotational structure by methods similar to those applied by Harvey⁶ in the case of CaF.

Magnesium has isotopes of masses 24, 25 and 26 in the abundance ratio 7 : 1 : 1. Two very faint heads have been found, at $\lambda 2636.84, 2637.30$ adjacent to the 1,0 head of the $\lambda 2689$ system, which agree within the error of measurement with the positions expected for the heads of the Mg ${}^{25}\text{F}$ and Mg ${}^{26}\text{F}$ 1,0 bands. We expect to obtain plates showing stronger absorption to confirm this result. Experiments are now in progress on the absorption of BeF, in order to decide if possible the question of the existence of the isotope Be⁸. The evidence for this isotope has recently been questioned, and the absorption spectrum should furnish the most sensitive test for its presence.

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Department of Physics,
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⁵ F. A. Jenkins, Phys. Rev. **35**, 315 (1930).

⁶ A. Harvey, Proc. Roy. Soc. **A133**, 336 (1931).

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The Metastable 2D -Level of the Nitrogen Atom

The nitrogen atom (N I) has three low levels, the ${}^4S, {}^2D$ and 2P , all of which converge to the 3P term of the N^+ ion. The first of these, the 4S term, is the ground state and its value is known accurately; the 2D and 2P terms are metastable and the separation of the doublet terms in each case has been estimated¹ but not experimentally verified. Each of the three levels corresponds to an electron configuration of $2s^22p^3$. The higher 2P term ($2p^23s$) combines with the 2D term with the emission of a doublet at 1495 and 1492A. Since the 2D level is a metastable one, it is possible to obtain these lines as absorption lines and through self-reversal to measure accurately the doublet separation ${}^2D_{2\frac{1}{2}} - {}^2D_{1\frac{1}{2}}$.

A spark of about 1 mm length was produced between metal electrodes (aluminum, copper) in flowing nitrogen at atmospheric pressure. The spark was placed from 6–10 mm in front of the fluorite window of a Hilger vacuum spectrograph whose dispersion is 2A per mm at 1500A; the exposure time varied from 1 to 4 minutes and the photographs were taken on Schumann plates made by Hilger. A photographic enlargement of the 1495–1492A doublet (Fig. 1) shows a single absorption line on the broad background of the emission line at 1495A and two absorption lines on the 1492A emission line. With the wave-length obtained from Ekefors' measurements,¹ $\lambda_1 = 1494.675\text{A}$, as the basis of our measurements, $\lambda_2 = 1492.79\text{A}$ and $\lambda_3 = 1492.59\text{A}$. The photograph shows that the intensity of λ_3 is greater than λ_2 , indicating that the 2D term is inverted, as might be expected. The more probable transition, ${}^2P_{1\frac{1}{2}} - {}^2D_{2\frac{1}{2}}$, would correspond therefore to the shorter wave-length. The frequency separation of the two 2D terms is $8.9 \pm 0.1 \text{ cm}^{-1}$. From analogy with the separa-

tion of corresponding terms in the O II spectrum, Compton and Boyce¹ estimated the probable separation as 5 cm^{-1} ; the measurements of Ekefors¹ seem to indicate a separation of 7 cm^{-1} .

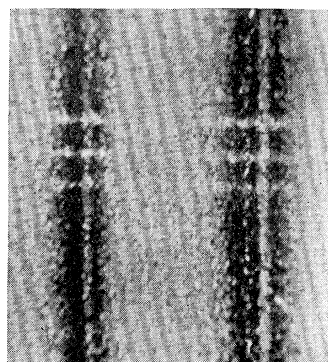


FIG. 1.

Reference to Fig. 1 shows that the line 1495 is strongly asymmetric, the middle of the emission line being shifted 0.06A or 2.7 cm^{-1} in relation to the center of the absorption line. As this shift is toward the red it cannot be explained by the appearance of the forbidden line ${}^2D_{2\frac{1}{2}} - {}^2P_3$. It was not possible to investigate thoroughly the reason for this

¹ E. Ekefors, Zeits. f. Physik **63**, 437 (1930); K. T. Compton and F. C. Boyce, Phys. Rev. **33**, 145 (1929); S. B. Ingram, Phys. Rev. **34**, 421 (1930).