conditions stated, is about 2°K, and then only if the parallel capacity C_1 of the resonant circuit can be made precisely $0.02\mu f$ and the associated network components are designed to give a resonance at 1600 c/s.

It may be possible to reduce the measurable T_a below 2°K. A tube might be designed around Eqs. (1), (2), and (3) which would have better properties for this application than the D-96475; furthermore, if this tube could be inserted in the low temperature bath along with the resonant circuit (R, X in Fig. 1), C_2 might be lowered to $6\mu\mu f$; perhaps also the background could be measured or balanced out to better than one percent. A scrutiny of these possibilities leads, however, to the conclusion that the ultimate attainable temperature will almost certainly be greater than 0.1°K. It must be noted, however, that these calculations depend on the assumption that the noise arising in the portion of the circuit at temperature T_b can be accurately determined or balanced out. If this is not possible, the minimum temperature measurable by this method may be very much higher.

* Bulletin of the American Physical Society 21, 6 (1946).
[1] A. W. Lawson and E. A. Long, Phys. Rev. 70, 220 (1946).
[2] This conclusion was arrived at independently by J. B. Brown and D. K. C. MacDonald, Phys. Rev. 70, 976 (1946).
[3] F. B. Llewellyn, Proc. I.R.E. 18, 243 (1930).
[4] D. O. North, RCA Review 4, 441 (1946).
[5] F. E. Terman, Radio Engineers' Handbook, first edition, p. 316.

On Bringing the Beam out of a Betatron

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COURANT and Bethe[1] have given a brief discussion of their theoretical considerations on bringing the electron beam out of a betatron. I should like to mention that in the autumn of 1944 I made similar considerations and came to the same conclusion that the deflection electrodes for bringing out the beam should be located quite near the point where Br is a maximum. If the simplifying assumption is made that Br follows a parabolic law, for instance $Br = (Br)_{max}(1-\alpha\rho^2)$, with ρ indicating the distance from the point r_m where Br is a maximum, while the magnetic guiding field must vary (relative to the induction field) with the time constant T (for example, as $B_{\Delta t}=B_0(1-\Delta t/T)$, then as a first approximation the following differential equation for the electron orbits is obtained.

$$\frac{\partial^2\rho}{\partial t^2}=\frac{V^2}{r_m}\left(\alpha\rho^2+\frac{\Delta t}{T}\right)$$

where V is the tangential velocity of the electrons at the radius r_m.

This corresponds to the so-called Painlevé differential equation $y''=y^2+x$, which cannot be solved by known functions. Figure 1 shows a solution of this differential equation, the initial conditions being so selected that the electrons do not execute any superposed oscillations. It will be seen that the curve for y' (which also corresponds to the separation of the single orbits) rises very steeply when the radius r_m is exceeded (about proportionality to $y^{\frac{3}{2}}$). In order therefore that the divergence of the emerging
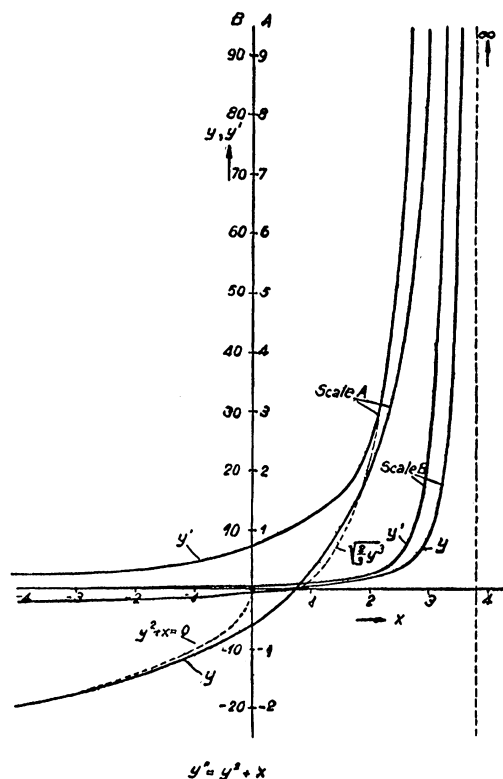

FIG. 1. Graphical form of the solution of the equation $y''=y^2+x$.

electrodes should not become too large, the deflecting electrodes must not be located too far outside the circle r_m. On the other hand, in order that too many electrons do not fall on the edge of the deflecting plate, this latter must not be placed too far inwards.

These two conditions result in an optimum position for the deflecting plates which, in conjunction with a particular construction of the deflecting field (preliminary deflection by means of a special very thin deflecting electrode), has formed the subject matter of a patent application filed by me in December, 1944. In this patent application also the refocusing of the emerging beam by means of an auxiliary magnetic field has been provided.

[1] E. D. Courant and H. Bethe, Phys. Rev. 70, 798 (1946).

On the Dissociation Energy of CO

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THREE proposed interpretations of the band spectrum of CO lead to $D(CO)=6.92$ ev,[1] 9.14 ev,[2] and 11.11 ev,[3] respectively. Electron collision experiments in CO give the unique value, $D(CO)=9.6$ ev.[4] Clearly a reconciliation of these conflicting positions is demanded.

$D(CO)=9.6$ ev from electron impact rests upon the appearance potentials of four ionization and dissociation

processes studied by a retarding potential method[5] and the mass spectrometer[4] with excellent numerical agreement. Similar studies in H_2, N_2, NO, and O_2 with the same apparatus are in excellent agreement with well-established results from the band spectrum. It is contended that to demand a discrepancy of 0.5 ev in the single case of CO, as is required by any of the present interpretations of the band spectrum, does considerable violence to an otherwise consistent and well-established body of data.

The spectroscopic determinations of $D(CO)$ are based on interpretations of a number of intensity weakenings or breakoffs in the rotational structure of emission bands. These occur 9.61 ev above $X\,^1\Sigma^+$ in $v'=7$, 8, and 9 of $A\,^1\Pi$; 11.11 ev above $X^1\Sigma^+$ in $v'=0$, 1 of $B\,^1\Sigma^+$ and $v'=0$, 1 of $b\,^3\Sigma^+$; and 11.58 ev above $X\,^1\Sigma^+$ in $v'=0$ of $C\,^1\Sigma^+$. An interpretation of these data is proposed here which is consistent with $D(CO)=9.6$ ev and which, it would appear, is at least as credible as any of the present interpretations.

If $D(CO)=9.6$ ev, there are dissociation limits of the molecule corresponding to the products $C(^3P)+O(^3P)$ at 9.6 ev, $C(^1D)+O(^3P)$ at 10.86 ev, $C(^3P)+O(^1D)$ at 11.58 ev, etc. Thus the effects in the spectrum at both 9.61 and 11.58 ev could be genuine predissociations at the corresponding dissociation limits. The effect at 11.11 ev, however, cannot occur at a dissociation limit.

It is suggested that $B\,^1\Sigma^+$ and $b\,^3\Sigma^+$ are predissociated by $a'\,^3\Sigma^+$ [Case I(b)], as has been supposed, but that $a'\,^3\Sigma^+$ has a potential curve with maximum, the maximum occurring at the predissociation in $B\,^1\Sigma^+$ and $b\,^3\Sigma^+$ and the convergence of the vibrational levels of $a'\,^3\Sigma^+$ at 11.11 ev. The dissociation limit of the state would in all probability be $C(^1D)+O(^3P)$ at 10.86 ev, requiring the maximum to be 0.25 ev high.

It is known that a criterion for a potential curve with maximum is the form of the so-called limiting curve of dissociation which must be a straight line of slope predicting a reasonable value for the internuclear distance (r_m) at which the maximum occurs.[6] If one accepts all the intensity changes reported[7] in the $B\,^1\Sigma^+$ and $b\,^3\Sigma^+$ states as predissociation by $a'\,^3\Sigma^+$ one can draw a straight line through the data but of slope giving $r_m=3.8$A, an impossibly high value. However, it is to be observed that the four data on which this curve is based are by no means of equal credibility. The breakoffs in $v'=0$ of $B\,^1\Sigma^+$ and $v'=1$ of $b\,^3\Sigma^+$ are observed in the P, Q, and R branches and can hardly be questioned. That in $v'=1$ of $B\,^1\Sigma^+$, on the other hand, is observed only in the P branch of the (1, 0) and the Q branch of the (1, 1) angström bands in which considerable superposition by CO_2 bands occurs. Considering these to result from a perturbation and not predissociation by $a'\,^3\Sigma^+$, one can obtain $r_m=2.9$A, a quite reasonable value. It should be remarked that since $D(a'\,^3\Sigma^+)>4$ ev a maximum only 0.25 ev high would be expected to lie at quite large internuclear separation.

Attributing the breakoffs in $v'=1$ of $B\,^1\Sigma^+$ to a perturbation or perhaps another predissociation is certainly no less tenable than attributing the breakoffs in the three levels $v'=7$, 8, 9 of $A\,^1\Pi$ at 9.61 ev to accidental predissociation or a perturbation as is now required by $D(CO)$

$=9.14$ or 11.11 ev. If, in addition, it should be found that the failure of Dieke and Mauchly[8] to follow the structure of bands with $v'=0$ of $b\,^3\Sigma^+$ to $K>55$ is the result of something other than a predissociation by $a'\,^3\Sigma^+$ as is now supposed,[9] it would be possible to draw a straight-line limiting curve through the two remaining and most trustworthy sets of points having a slope which gives r_m as small as 2.1A. This may not be necessary to the interpretation, however.

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[4] H. D. Hagstrum and J. T. Tate, Phys. Rev. 59, 354 (1941).
[5] W. W. Lozier, Phys. Rev. 46, 268 (1934).
[6] See G. Herzberg, Molecular Spectra and Molecular Structure (Prentice Hall, New York, 1939), pp. 444–459.
[7] See summary by L. Gerö, Zeits. f. Physik 100, 374 (1936).
[8] G. H. Dieke and J. W. Mauchly, Phys. Rev. 43, 12 (1933).
[9] F. Brons, Nature 135, 873 (1935); L. Gerö, Zeits. f. Physik 95, 747 (1935).

A Mass Spectroscopic Analysis of the Polyatomic Gases in a Fast Counter

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THE function of the polyatomic gas in a fast counter as proposed by S. A. Korff and R. D. Present[1] has a twofold purpose: (1) to quench the ultraviolet photons that are emitted by the excited states of the inert gas (argon) and (2) to quench secondary emission by positive ions reaching the cathode. The authors point out that the characteristic property of a polyatomic molecule which is of importance in the counter is the large probability of predissociation from excited electronic states. They claim that the quenching of ultraviolet photons in the initial avalanche occurs through the photo-decomposition of the polyatomic gas, and the electron transfer probability ensures that the positive ion sheath, when it reaches the cathode, is composed entirely of polyatomic ions. These are neutralized at about 10^{-7} cm from the wall and the excited neutral molecules predissociate in 10^{-13} sec. before they can liberate a secondary electron by an inelastic collision with the wall or by recombination radiation. The authors point out that since no supply of secondary electrons is available the discharge terminates.

Korff and Present suggest that the primary decomposition products of the polyatomic molecules are free radicals which combine to form a miscellaneous assortment of organic molecules. They claim that some of these decomposition products will be quenching gases; however, with continued use of the counter all of the larger vapor molecules will be broken up and the end products of the decomposition are a non-quenching gas of much smaller molecular weight.

Partly to verify this theory two argon-ethyl acetate counters (argon pressure 8 cm, ethyl acetate pressure 1.2 cm) were prepared simultaneously on a Geiger counter filling system. One counter was kept unused and the other was run for 10^{10} counts, when it no longer acted as a self-