STUDIES IN THE INHERITANCE OF RESISTANCE TO RUST OF BARLEY.

Part II.

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Introduction.

In an earlier paper in these *Proceedings* (Waterhouse, 1927), results from several crosses between barley varieties were presented which showed that a single dominant genetic factor determined resistance to *Puccinia anomala* Rostr., the cause of barley leaf rust. There was no evidence of linkage with factors determining certain morphological characters studied.

Although much genetical work on barley has since been reported, there are apparently no records of other work on inheritance of rust resistance. The work now presented deals with a continuation of the original studies and carried forward between the years 1924 and 1941. An extensive programme of work had been planned. It later became impossible to carry it through to completion, and as it is now not intended to continue the barley work, it seems wise to make the results obtained available to other workers.

Materials and Methods.

With a few additions, the barley varieties already classified for resistance (Waterhouse, 1927) were used. Pots of seedlings were inoculated in the usual way and the rust reactions in the plant house determined on the scale generally adopted. Parent varieties were used for direct comparison with the cross-bred material sown at the same time and kept under comparable conditions. This is necessary because alterations in the environmental conditions change the reactions shown in certain cases ; this applies particularly to the group of barleys classified as being " moderately resistant " to *P. anomala*. Reactions recorded in May as " 2 " change to " 4 " in February, when much higher temperatures prevail : intermediate reactions like " 2+ ", " X " and " 4^c " are shown under intermediate conditions of light and temperature. Many of the " resistant " varieties exhibited no such variation, remaining resistant and showing " O " (flecks) under all the temperature conditions tested.

Crosses were made in the field. F1 plants after being tested in pots in the plant house were transplanted to open plots and grown to maturity. The same was done with the back-cross and certain of the F2 plants used in the F3 tests ; others of these were grown from grain sown directly in the open—not tested as F2 individuals.

The culture of *P. anomala* used was the same as that reported upon previously. During the period, nine cultures derived from a number of sources were tested on an empirically selected group of " moderately resistant " and " resistant " varieties, but no departure from the behaviour shown by the stock culture was found. At the time, the set of differential varieties worked out by D'Oliveira had not been obtained.

For the stem rust tests, the standard cultures maintained for the wheat rust work were used on the barleys.

Experimental Results.

(a) *Tests with* P. anomala.

F1 Results.

1. Crosses were made between two susceptible parents as follows :

Parents.		No. of Seedlings Tested.
Kinver	× Pryor	23
,,	× Cape	10
,,	× Skinless	14
,,	× Trabut	2
Cape	× Kinver	4
,,	× Skinless	13
,,	× C.I. 2329	3
,,	× Peatland	14
Skinless	× Success	11
,,	× Bel. 2071	5
Volga	× *Hordeum spontaneum*	9
,,	× Reka	7
Reka	× Volga	6
C.I. 2309	× C.I. 2222	23
,,	× Cape	8
Golden Grain	× Mariout	3
Luth	× C.I. 2237	16

In all cases the F1 plants were susceptible ; no difference between their reactions and those of the parents could be detected.

2. One cross between two "moderately resistant" parents was made. Minn. II 20.10B × Minn. II 21.14 gave seedlings showing a "2+" reaction similar to that of the parents tested at the same time.

3. Crosses between two "resistant" parents were made as follows :

Parents.		No. of Seedlings Tested.
Minn. II 21.15	× O.A.C. 21	12
,,	× Manchuria	12
Minn. II 21.17	× O.A.C. 21	31
,,	× Manchuria	15
Manchuria	× Minn. II 21.17	19
,,	× Virginia Hooded	5
O.A.C. 21	× Manchuria	18
,,	× Virginia Hooded	2
Virginia Hooded	× Manchuria	6

The reactions of the parents showed variations from "0" (flecks) to "1" reactions within the same pot. No differences of any significance were shown by the F1 plants.

4. Crosses between a "resistant" and a "moderately resistant" parent were made as follows :

Parents.		No. of Seedlings Tested.
Minn. II 21.15	× Minn. II 21.14	15
Minn. II 21.14	× Minn. II 21.15	15
O.A.C. 21	× California Feed	27
Virginia Hooded	× Success	1

In these cases the F1 reactions were not significantly different from the "0" to "1" reactions of the resistant parent.

5. Crosses between a susceptible and a "moderately resistant" parent were made as follows:

Parents.		No. of Seedlings Tested.
Cape	× California Feed	15
Skinless	× ,,	12
Kinver	× ,,	23
Minn. II 20.10B	× Kinver	23
,,	× Minn. II 21.14	4
Minn. II 21.14	× Kinver	10
Marionet	× Skinless	15
Minn. I 16.13	× Kinver	15
Coast	× ,,	14
Sahara 3770	× ,,	24
Locride	× ,,	11
Psaknon	× ,,	16
Orge Fourragère	× ,,	13

The F1 reactions were of the "2+" type, being practically the same as those of the "moderately resistant" parents. These, as pointed out earlier, give reactions that are subject to considerable variation with temperature change: in mid-summer the reaction has to be classed as "4". In a few cases F1 tests were made under these conditions, and then the reactions were also of the "4" type.

6. Crosses between a susceptible and a "resistant" parent were made as follows:

Parents.		No. of Seedlings Tested.
Minn. II 21.15	× Skinless	10
,,	× Cape	9
Cape	× Minn. II 21.15	12
Minn. II 21.17	× Skinless	30
Skinless	× Minn. II 21.17	11
C.I. 2208	× C.I. 2209	10
,,	× C.I. 2237	19
,,	× Skinless	25
Skinless	× C.I. 2208	26
C.I. 2220	× Skinless	8
Skinless	× C.I. 2220	6
C.I. 2220	× C.I. 2222	12
Manchuria Sel. C163	× Skinless	14
Skinless	× Manchuria Sel. C163	35
Manchuria Sel. C163	× Cape	30
,,	× Manchuria Sel. C225	15
,,	× Kinver	19
,,	× Manchuria Sel. C81	13
O.A.C. 21	× Skinless	50
Skinless	× O.A.C. 21	28
O.A.C. 21	× Cape	45
Virginia Hooded	× Volga	27
Volga	× Virginia Hooded	5
Virginia Hooded	× Luth	46
,,	× Intermediate	43
,,	× Weider	14
,,	× Bel. 2071	13
Colsess	× Skinless	29
Manchuria	× Pryor	28
,,	× Cape	19
Manchuria Sel. C168	× ,,	3
No. 22	× ,,	17
Minn. II 21.18	× Pusa No. 1	5
Bolivia	× Cape	12
Weider	× Skinless	9
Skinless	× Weider	11

The reaction of the "resistant" parents varied from "0" to "1" and was hardly distinguishable, if at all, from those shown by the F1 plants.

Summary of the F1 Results.

The evidence shows that there is dominance of resistance to *P. anomala.* This applies to the " resistant ", as well as the " moderately resistant " varieties from whatever source.

Back-cross Results.

1. A back-cross between Skinless and the F1 of (Skinless × Manchuria Sel. C163) gave a total of 12 plants resistant, showing reactions " 0 " to " 1 " and 11 plants susceptible, showing " 4 " reactions. Progenies of only 5 of these plants were available for further tests. Three from susceptible parents gave a total of 258 tested plants, all of which were susceptible. The other 2 came from resistant plants ; one gave 34 resistant and 14 susceptible plants and the other 36 resistant and 12 susceptible plants.
2. Skinless × (Skinless × O.A.C. 21) yielded 17 resistant and 23 susceptible seedlings.
3. Pryor × (Pryor × Manchuria) gave 6 resistant and 7 susceptible plants.
4. Minn. II 21.14 × (Minn. II 21.14 × Minn. II 21.15) gave 4 resistant and 5 susceptible plants.

The numbers of individuals dealt with are small, but the results point to a single dominant factor for resistance operating.

F2 Results.

1. Crosses between Two Resistant Parents.

(*a*) A cross between O.A.C. 21 and Minn. II 21.17 gave 208 plants classified as " 0 " to " 1 ", these being similar to the reactions of each parent.

(*b*) The cross Manchurian × Minn. II 21.17 yielded 224 resistant seedlings classified as " 0 " to " 1 ", similar to the parent reactions.

(*c*) The cross Manchurian × O.A.C. 21 yielded 245 resistant plants similar in resistance to the parents.

2. Crosses between " Resistant " and " Moderately Resistant " Parents.

The results may be summarized in the following table :

Parents and Their Reactions.	Counts of F2 Plants.				Deviation from 3 : 1 Ratio.
	Re-sistant.	Re-action.	Moderately Resistant.	Re-action.	
Californian Feed, " 2+ " × O.A.C. 21, " 0 " to " 1 ".	157	" 0 " to " 1 "	55	" 2+ " to " X "	2
Minn. II 21.14, " 4c " × Minn. II 21.15, " 0 " to " X ".	171	" 0 " to " X− "	61	" 4c "	3
Minn. II 21.15, " 0 " to " X− " × Minn. II 21.14, " 4c ".	149	" 0 " to " X− "	48	" 4c "	1
Minn. II 21.14, " 4c " × Manchuria, " 0 " to " X− ".	196	" 0 " to " X− "	67	" 4c "	1
Cape, " 2+ " × O.A.C. 21, " 0 " to " 1 ".	142	" 0 " to " 1 "	40	" 2+ "	5
Minn. II 21.15 " 0 " to " 1 " × Cape " 2+ ".	72	" 0 " to " 1 "	18	" 2+ "	5
Cape, " 2+ " × Manchuria Sel. C163 " 0 " to " 1 ".	137	" 0 " to " 1 "	37	" 2+ "	6

The results show the operation of a single dominant factor determining " resistance ".

3. Crosses between "Moderately Resistant" and Susceptible Parents.

The results may be summarized as follows:

Parents and Their Reactions.	Counts of Plants.				Deviation from 3 : 1 Ratio.
	Moderately Resistant.	Re-action.	Sus-ceptible.	Re-action.	
Cape, "4c" × Californian Feed, "X"	165	"X"	52	"4c"	2
Kinver, "4" × Californian Feed, "X"	67	"X"	19	4	2
Kinver, "4" × Minn. II 21.14, "X+"	111	"X+"	35	4	2
Kinver, "4" × Marionet, "X" ..	83	"X"	34	4	5
Kinver, "4" × Sahara 3770, "X"	174	"X"	66	4	6
Kinver, "4" × Psaknon, "X" ..	52	"X"	18	4	1

The results show the operation of a single dominant factor determining "moderate resistance".

4. Crosses between "Resistant" and Susceptible Parents.

The results may be summarized as follows:

Parents and Their Reactions.	Counts of F2 Seedlings.				Deviation from 3 : 1 Ratio.
	Re-sistant.	Re-action.	Sus-ceptible.	Re-action.	
Skinless, "4" × Minn. II 21.15, "0" to "1".	173	"0" to "1"	54	4	3
Minn. II 21.15, "0" to "1" × Skinless "4".	137	"0" to "1"	44	4	1
Skinless, "4" × Minn. II 21.17, "0" to "1".	313	"0" to "1"	120	4	12
Skinless, "4" × C.I. 2208, "0" to "1".	158	"0" to "1"	65	4	9
C.I. 2208, "0" to "1" × Skinless "4".	149	"0" to "1"	59	4	7
Skinless, "4" × C.I. 2220, "0" to "1".	22	"0" to "1"	7	4	—
Skinless "4" × Manchuria Sel. C163, "0" to "1".	182	"0" to "1"	62	4	1
Manchuria Sel. C163, "0" to "1" × Skinless "4".	239	"0" to "1"	78	4	1
O.A.C. 21, "0" to "1" × Skinless "4".	208	"0" to "1"	82	4	9
Cape, "4" × Minn. II 21.15, "0" to "1".	26	"0" to "1"	14	4	4
Cape, "4" × O.A.C. 21, "0" to "1".	194	"0" to "1"	47	4	13
Kinver, "4" × Manchuria Sel. C163, "0" to "1".	63	"0" to "1"	19	4	2
Totals	1,864		651		22

In all cases the deviation from the expectancy for a 3 : 1 ratio is less than twice the S.E. The results show the operation of a single dominant factor for resistance.

In three of the crosses, the F2 plants after testing were grown to maturity and their morphological characters determined in regard to beard, hulled grain and smooth awn. Rust resistance was inherited independently of any of these features.

F3 Results.

Progenies of three of the crosses studied in the F2 were examined with the following results :

Parents of Cross.	Classification of F3 Families.					
	Homozygous Resistant.	Average No. of Plants Tested.	Heterozygous Resistant.	Average No. of Plants Tested.	Homozygous Susceptible.	Average No. of Plants Tested.
(*a*) Skinless × Minn. II 21.15	56	26	98	24	52	19
Expectancy ..	51·5		103		51·5	
(*b*) Cape × Minn. II 21.15	6	20	21	27	10	25
Expectancy ..	13·25		26·5		13·25	
(*c*) Skinless × Minn. II 21.17	20	29	40	25	27	31
Expectancy ..	21·75		43·5		21·75	

Summation of Individuals in the Heterozygous F3 Families.

Parents of Cross.	Resistant.	Susceptible.	Deviation from 3 : 1 Ratio.
Skinless × Minn. II 21.15	1,802	612	8
Cape × Minn. II 21.15	409	160	18
Skinless × Minn. II 21.17	759	248	4
Total	2,970	1,020	22

In all cases the deviation from the expectancy on a 3 : 1 basis is less than twice the S.E.

Again there is clear evidence of the operation of a single dominant factor for resistance.

Summary of Leaf Rust Results.

The evidence from the F1, back-cross, F2 and F3 results points clearly to resistance depending upon a single dominant gene. The crosses used involved parents from widely scattered areas. There is nothing in the evidence to show that it is not the same gene in the many varieties used. Additional crosses between resistant sorts would be necessary to complete the evidence. This barley leaf rust result is entirely different from that obtained in the wheat leaf rust studies (unpublished data) where at least two major genes operate.

(*b*) *Tests with* Puccinia graminis tritici.

Seedling tests in the plant house do not give anything like the clear-cut reactions that are obtained with *P. anomala*; varieties which are quite susceptible show a considerable amount of chlorosis; this is general. The pustule size is the chief distinguishing feature. Again, temperature changes bring about marked alterations in the reactions. Thus a "2" in winter may increase to a "$2\pm$" reaction in summer; the latter pustule is quite a large one with considerable uredospore formation on the chlorotic areas.

Varieties were classified on the basis of their reactions to the three races of *P. graminis tritici* numbered 34, 43 and 45, as well as to *P. anomala.* Under the conditions prevailing at the time of the test, some varieties gave only "1=" reactions; the reaction "2" was taken as setting the upper limit to the resistant class. It was sometimes difficult to determine whether a "2" reaction was significantly different from a "2+" reaction which was taken as the lower limit in the susceptible class.

Based on such "resistance" and "susceptibility", 13 of the 16 possible groupings were found, as follows:

1. *Resistant to* P. anomala *and* P. graminis tritici *races 34, 43, 45.*
   Virginia Hooded, Coast.
2. *Susceptible to* P. anomala *and* P. graminis tritici *races 34, 43, 45.*
   Luth, C.I. 2222, Trabut, Mariout, Volga, Standwell, Hero, Intermediate, Pearl, Chedret, Coutsopodi, Janina, Sahara 3764, Sahara 3765, Burton's Malting.
3. *Resistant to* P. anomala *and Susceptible to* P. graminis tritici *races 34, 43, 45.*
   Minn. II 21.15, Minn. II 21.17, Manchuria Sel. C168, Manchuria Minn. 184, Manchurian, O.A.C. 21, No. 22, Orge 4th.
4. *Susceptible to* P. anomala *and Resistant to* P. graminis tritici *races 34, 43, 45.*
   C.I. 2256, C.I. 2269, C.I. 2209, C.I. 2210, C.I. 2237, C.I. 2280, C.I. 2226, C.I. 2228, Manchuria Sel. C225, Cape, Kinver, Golden Grain, Albert, Princess, Goldthorpe, Tunis, Gatama, Roseworthy Oregon, Squarehead.
5. *Resistant to* P. anomala *and* P. graminis tritici *34 and 45, and Susceptible to* P. graminis tritici *34.*
   C.I. 2220.
6. *Resistant to* P. anomala, P. graminis tritici *43, 45 and Susceptible to* P. graminis tritici *34.*
   C.I. 2208, Manchuria Sel. C163, Colsess, Orge Fourragére.
7. *Resistant to* P. anomala *and* P. graminis tritici *45 and Susceptible to* P. graminis tritici *34, 43.*
   Minn. II 21.18, No. 305, Orge 14J.
8. *Susceptible to* P. anomala *and* P. graminis tritici *34 and Resistant to* P. graminis tritici *43, 45.*
   Black Russian, C.I. 2206, Nepal, C.I. 2254, Gold, Salonika, Sahara 3766, Sahara 3768, Gisborne, Tennessee Winter, Hanchen.
9. *Susceptible to* P. anomala *and* P. graminis tritici *43 and Resistant to* P. graminis tritici *34 and 45.*
   C.I. 2213, C.I. 2215, C.I. 2217, Zea.
10. *Susceptible to* P. anomala *and* P. graminis tritici *45 and Resistant to* P. graminis tritici *34, 43.*
    C.I. 2229, Nodding Barley.

11. *Susceptible to* P. anomala *and* P. graminis tritici *34, 43 and Resistant to* P. graminis tritici *45.*

C.I. 2204, C.I. 2214, C.I. 2219, C.I. 2221, Manchuria Sel. C81, Skinless, Pryor, Reka, *H. spontaneum*, Purple Hull-less, Shorthead, Chilian, Kaylaria, Sahara 3767, Sahara 3769, Erect Eared Barley, Himalaya, Orzo Nuda Putignans, Orzo Maraina, White Hull-less, Duckbill, Garton's Regenerated Maltster.

12. *Susceptible to* P. anomala *and* P. graminis tritici *34, 45 and Resistant to* P. graminis tritici *43.*

No. 78, Larissa.

13. *Susceptible to* P. anomala *and* P. graminis tritici *43, 45 and Resistant to* P. graminis tritici *34.*

No. 49, Primus, Meloy.

F1 Tests of Resistance to P. graminis tritici.

A number of crosses were made for these studies, based upon the reciprocal reactions shown to the four rusts. The F1 plants were tested and grown to maturity. It then became impossible to prosecute the studies, and later generation tests could not be made.

In the F1 tests of 37 crosses selected for their reciprocal resistance and susceptibility, there was dominance of resistance to race 43, and of susceptibility to races 34 and 45. No correlation with resistance to *P. anomala* was found. This also applied to three of the crosses in which resistance to *Erysiphe graminis hordei* was also involved.

Resistance of Erysiphe graminis hordei.

The occurrence of powdery mildew in the planthouse led to inoculation tests being carried out for resistance to *E. graminis hordei.* Later this was checked by recording the field behaviour in respect of the disease.

The following varieties were found to be resistant: C.I. 2269, C.I. 2215, C.I. 2237, C.I. 2280, C.I. 2218, C.I. 2250, Lion, No. 22, Psaknon, White Hull-less, Bolivia, C.I. 2329, Juliaca, Coast, Portuguese, Goldfoil, Hanna, Bark, Bolivia, Bel. 2071, Duplex, 017, Kwan, Weider.

Summary.

Further studies are reported of resistance to leaf and stem rusts, and to a small extent to powdery mildew of barley.

Numerous F1 tests, with fewer back-cross, F2 and F3 studies, confirm the action, in the crosses studied, of a single dominant factor for resistance to *P. anomala.* This applies to varieties obtained from widely scattered sources.

Many F1 tests showed dominance of resistance to *P. graminis tritici* race 43, and of susceptibility to races 34 and 45 of this rust.

In the cases studied there was no evidence of correlation between leaf and stem rust or with certain morphological characters that were examined.

Reference.

Waterhouse, W. L., 1927. This Journal, **61**, 218.

CORROSION OF SURFACES HEATED ABOVE THE BOILING POINT OF THE CORRODANT.

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The process of matter loss which occurs during the corrosion of metals appears to be controlled by many physical factors analogous to those which control the convective heat loss from geometrically similar hot bodies. When the temperature of a hot body immersed in a liquid is steadily raised beyond the boiling point of the liquid the curve of the emittance, and therefore the rate of boiling, plotted against the temperature takes a characteristic form. With rising temperature just beyond the boiling point there is first a steady rise in the emittance. At a certain temperature, however, a change occurs from film to nuclear boiling with an associated sudden drop in the emittance, which thereafter steadily rises with rising temperature. The work described in this note sets out to see if the rate of loss of matter by corrosion shows a similar behaviour when the temperature of the body subject to corrosion is slowly raised past the point at which nuclear boiling commences.

The Experimental Method.

In the experimental measurement of corrosion from surfaces heated above the boiling point of the corrodant a hot wire device was used. The wire was heated by means of an electric current to a temperature which could be measured from the electrical resistance. Further, the rate of corrosion could be measured in terms of the rate of change of this resistance.

The wires examined were copper, the corrodants glacial acetic acid and acetic anhydride. A 5 cm. length of fine wire (38-46 gauge S.W.G.) was clamped on to current leads of the same metal. The clamps also held lighter voltage leads of the same metal. The specimen with its four leads was mounted in a cork stopper which fitted into a wide test tube containing the corrodant under examination. The test tube was mounted in a thermostatic bath maintained at the boiling point of the corrodant. The heating current was passed through a controlling resistance, an ammeter and the wire under test; and thus served to heat the wire above the boiling point of the corrodant and cause the liquid to boil on the wire. A voltmeter connected across the voltage leads enabled the resistance of the wire to be read. The quotient of the resistance obtained with the normal heating current over the resistance obtained with a very small current (of the order of 10 milliamps.) is a measure of the temperature (θ) above the boiling point of the liquid.

Theory of the Method.

In an experimental run three measurements are taken—the time, the current I and the voltage drop V. The resistance R ($=V/I$) is related to the specific resistance (ρ) of the wire at the operating temperature T, and the radius (r) of the wire by

$$R=5\rho/\pi r^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

5 being the length (in cms.) of the heated wire. For a change dr in the radius

of the wire a volume 2π r dr is lost from every unit length of the wire. The rate of corrosion q (in units of grams per sq. cm. per sec.) is then given by

$$q = \delta \frac{dr}{dt} \qquad (2)$$

where δ is the density of the material of the wire. By substituting equation (2) in equation (1) we obtain

$$q = \delta \sqrt{\frac{5\rho}{\pi}} \frac{d(R^{-\frac{1}{2}})}{dt} \qquad (3)$$

The quantity R, it should be recalled, is the resistance of a 5 cm. length of wire. From equation (3) we see that, provided the corrosion proceeds at a constant rate as the wire thins, the quantity $R^{-\frac{1}{2}}$ should vary linearly with the time.

The heat generated per unit surface area by the electric current is proportional to $I^2R^{3/2}$, and provided this factor is kept constant as the wire thins we may expect a constant surface temperature. (It seems reasonable to assume that the thermal transmittance will not vary as corrosion proceeds.)

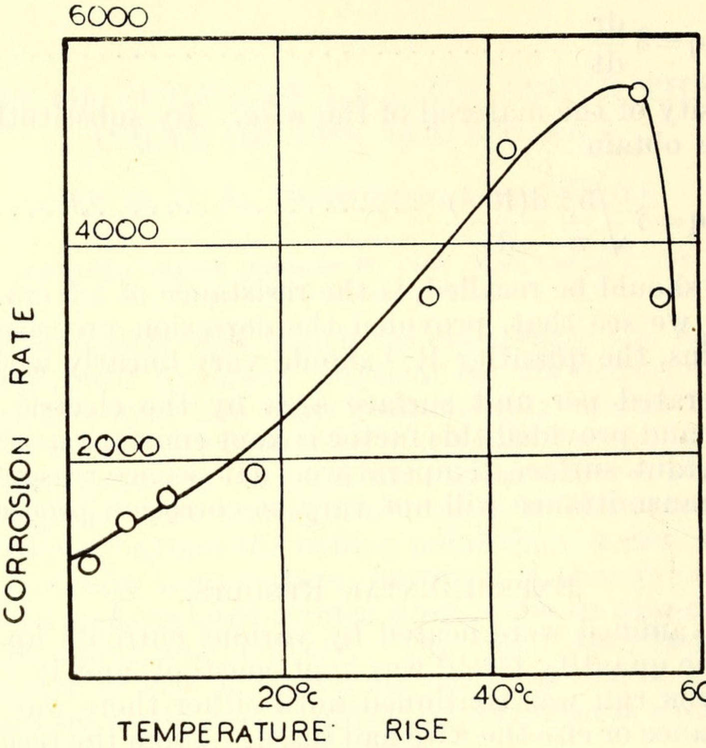
Experimental Results.

The samples examined were heated by various currents up to 20 amperes. On any fixed run the quantity $I^2R^{3/2}$ was kept constant, and $R^{-\frac{1}{2}}$ plotted against the time. Any given run was continued until either there was a ten per cent. change in the resistance or else the wire had fused. From the resistance measurements corrosion rates and temperatures were derived by the methods outlined above. The derived corrosion rates and temperatures (excess above the boiling point) are shown in the two figures. Figure 1 refers to copper in glacial acetic acid, and Figure 2 to copper in acetic anhydride.* It will be seen that the corrosion rates are quite large at the boiling points and rise steadily with further increase in the temperature, until, for temperatures of the order of 60° C. to 80° C. above the boiling point there is a sudden drop in the rate of corrosion, particularly in the case of acetic anhydride in which the rate of corrosion when the wire is 80° C. above the boiling point is only a small fraction of that when the wire is at the boiling point. Associated with this change in the rate is an equally obvious change in the chemistry of the reaction. At the lower temperatures copper dissolves to give a cupric salt which forms an intensely blue coloured complex with acetic anhydride. As soon as the temperature reaches the point at which the corrosion rate shows the sudden drop the blue colour begins to disappear and in its place there appears first a yellowish muddy fluid and finally a flocculent pink precipitate, apparently cuprous oxide or a basic cuprous acetate. Once the pink precipitate has formed no further corrosion apparently takes place and the supernatant liquid remains colourless. This is particularly remarkable in that the leads, which are not protected by a vapour film and have a surface area exposed to the liquid much larger than that of the hot wire, also appear to cease dissolving in the corrodant when attack on the hot wire ceases.

Discussion.

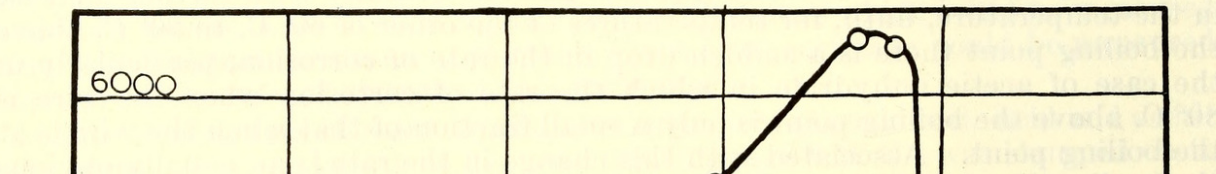
There are two points of interest in this work. In the first place it appears that a copper heating surface in acetic anhydride may be protected from corrosion if the temperature of the copper is high enough. One might compare this phenomenon with the drop in heat transfer coefficient which occurs when the temperature of a heating surface is made sufficiently high (see for example

* The corrosion rate in these two figures is measured in the customary units of mgrms. dec.$^{-2}$ day^{-1}.



6000
4000
2000
CORROSION RATE
20°c
40°c
60°c
TEMPERATURE RISE

Fig. 1.



6000
4000
2000
CORROSION RATE
20°c
40°c
60°c
80°c
100°c
TEMPERATURE RISE

Fig. 2.

Bosworth, 1946). Presumably the same cause is responsible for both phenomena, namely the formation of a complete vapour film over the surface.

In the second place these experiments give an interesting indication of the part played by the equilibrium between the cuprous and the cupric ions in the corrosion of copper. This subject has been treated by Gatty and Spooner (1938). In the oxidative reaction

$$Cu^{+} \rightarrow Cu^{++} + e^{-} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (A)$$

dissolved oxygen acts as the electron acceptor. The reverse reaction will only proceed at an appreciable rate heterogeneously at an interface. When this occurs at a copper-electrolyte interface a corrosive reaction is involved, namely

$$Cu^{++} + Cu^{\circ} \rightarrow 2Cu^{+} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (B)$$

It now appears that when the copper surface is covered with a vapour film, the reverse of equation (A) occurs at the vapour liquid interface leading to the reduction of cupric to the cuprous state without progressive attack on the copper surface.

References.

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