

Attachment VIII

The Scientific Principles of Lubricant Syntheses.

(report by Dr. H. Zorn, I. G. Leuna)

"Truly, Chemistry resembles the everchanging Proteus, who appears now as a Goddess and now as a capricious woman. But yet we tolerate her because behind her deceptive moods and playful ways she conceals immutable and eternal law."

These words were spoken by the great experimental chemist Ludwig Claissen on New Years of 1927 to his friend Anwers. In the same year I was transferred to the lubricants field and learned very soon of the "deceptive moods" of these substances which at that time really did "play games" with the chemist. In the following tables and charts I shall show you the laws behind the playful ways and how we succeeded in converting play into the serious business of synthesis.

The first attempt to produce lubricants synthetically dates back to the days of the first World War. At that time Dr. Schneider had attempted to produce lubricating oils by polymerizing the unsaturated constituents derived from brown coal generators. We resumed this type of work in 1926 by passing gaseous olefins into tar oils and hydrogenated oils in the presence of aluminum chloride. This process was actually carried out on a large experimental scale here in Leuna in the years 1930/31. Only ordinary machine oils were obtained, however, and no high quality engine oils. These experiments were nevertheless the starting point for extensive researches on the polymerization of chemically pure olefins of which the constitution was well known.

Fig. 1 (No. 42037)

In this chart you will see part of the results of these investigations. It will be noted that only straight-chain olefins with terminal double bonds give polymerizates in good yields, having a good viscosity-temperature-relation. The

yield is low and the V.I. poor when the double bond is located at the center of the molecule or when a hydrogen atom of the terminal double bond is substituted by an alkyl group. Dimethyl octylene is remarkable in that it yields a very viscous polymerizate in good yield. The results of this scientific investigation found industrial application in the polymerization of cracked paraffin.

In the vapor-phase cracking of paraffin, straight-chain olefins with a terminal double bond are formed. The polymerization of these olefins may be represented by the following scheme.

Fig. 2 (No. 45106)

In order to ascertain whether or not this scheme is correct, we attempted to prepare synthetically hydrocarbons of the type represented on the above chart. The synthesis developed by Dr. Metzger and Dr. Nienburg is shown in

Fig. 3 (No. 45113)

We started with octyl aldehyde which we converted by aldol condensation into hexyl-heptyl acrolein. The latter was reduced with a nickel-kieselgur catalyst to the corresponding alcohol; this alcohol was then converted with iodine and red phosphorus into the corresponding 2-hexyl-1 iododecane which was now reacted with the sodium salt of hexyl-malonic acid ethyl ester. The resulting ester was saponified, decarboxylated and the resultant acid again reduced to the alcohol. The alcohol was again converted into the iodide with phosphorous and iodine. This compound was then either reduced to hydrocarbon or again treated with the sodium salt of hexyl-malonic acid ethyl ester in order to build up the next higher homolog. In this somewhat cumbersome but nevertheless exact manner the hydrocarbons shown on Fig. 4 were prepared.

Fig. 4 (No. 57088)

It will be seen from the homologous series 1-5 that the viscosity increases with increasing molecular weight and that the viscosity-temperature relation improves

steadily. The same applies to the homologs 6, 7 and 8. These hydrocarbons are obtained from the iodides by the Wurtz synthesis. In this manner we were able to prepare a hydrocarbon $C_{64}H_{130}$ with a mol. wt. of 899. This molecular weight corresponds to that of high mol. wt. mineral and steam cylinder oils. The exact synthesis of a high-molecular hydrocarbon lubricating oil was thus accomplished for the first time. A remarkable feature of all these products is their low melting point, particularly that of the last mentioned hydrocarbon which melts at -39° .

Fig. 5 (No. 57080)

shows how the viscosity-temperature relation changes (for the same molecular weight) with variations in intramolecular branching of the carbon chain. It will be seen that the viscosity-temperature relation is improved as the number of side chains decreases.

Fig. 6 (No. 57086)

also shows the influence of branching on the viscosity-temperature relation for a constant molecular weight. The viscosity-temperature relation deteriorates as the branching and the viscosity increase. The more the shape of the molecules approaches that of a sphere, the less favorable is the action of temperature on viscosity.

Fig. 7 (No. 57084)

shows the same behavior for the C_{16} and C_{24} hydrocarbons. Short or branched side chains are very unfavorable, as is demonstrated by the hydrocarbons 10 and 9. The effect of short side chains on the melting point is very striking. We may compare the hydrocarbons 1-5. Here the introduction of the methyl group into hexadecane lowers the melting point some 57° . A second methyl group lowers it another 40° .

This brings out the difference between aliphatic and aromatic hydrocarbons, as is shown in

Fig. 8 (No. 51105)

Let us compare benzene, toluene and the xylenes. The viscosity-temperature relation is very poor when the straight carbon chain is entirely or partially closed to form a ring, as can be seen from the next chart.

Fig. 9 (No. 57081)

Here we see how a marked increase in viscosity and a pronounced decrease in viscosity-temperature relation is produced with increasing cyclization. Hydrocarbon No. 7 is particularly to be noted. These findings, based on laborious and painstaking synthetic work, prompted us to investigate technical application of these discoveries. The cracked paraffin polymerization process always gives us a mixture of olefins whose composition we cannot control.

This suggested ethylene. It had been shown by Dr. Otto that ethylene can be polymerized to n-butylene in the presence of small amounts of boron fluoride. We thought that if we used a more effective catalyst it might be possible to polymerize ethylene further, building up longer chains with long side chains. By using chemically pure ethylene it was possible to obtain (in the presence of aluminum chloride) polymerizates which combined a good viscosity-temperature relation with a good cold test. In this way the ethylene lubricating oil synthesis was evolved.

In testing the ethylene lubricating oils in practice it was found that under extreme lubricating conditions the lubricating power appeared not always to be sufficient. It is a well known fact in the mineral oil industry that the quality of mineral hydrocarbon lubricating oils can be improved in lubricating power by the addition of fatty oils. Fatty oils, that is, esters of glycerine and high molecular fatty acids, however, have the disadvantage of being extremely thermo-sensitive.

It was assumed that this thermal instability was caused by the sensitivity of the secondary hydroxyl groups of glycerine. Through the courtesy of the Director, Dr. Giesen, trimethylol ethane was placed at our disposal. The esters made therefrom with Leuna carboxylic acid had very good thermal stability. It thus seemed possible to prepare esters which would satisfy the high thermal requirements of aircraft engines. This successful development was one of the reasons for my transfer to Leuna where I could work on a broader basis with Dr. Lowenberg, Dr. Metzger, Dr. Ganicke, Dr. Neidinger, and Dr. (Miss) Rossig on the correlation of chemical constitution with the properties of esters.

Fig. 10 (No. 57089)

shows esters of trivalent and tetravalent alcohols, esterified with different acids. Let us first compare the esters of normal octylic acid. No differences except in cold test are found between trimethanol ethane and trimethanol propane in viscosity and in viscosity-temperature relation. The solidification point of trimethanol propane is 61° lower than that of trimethanol ethane. Glycerine is equivalent in the viscosity-temperature relation to the two alcohols, although the viscosity is lower, and the solidification point is much higher than that of trimethanol propane but lower than that of trimethanol ethane. Pentaerythritol gives an ester of considerably higher viscosity, still higher solidification point and a somewhat better viscosity-temperature relation. A comparison of the esters of the four alcohols with a branched chain acid, 2-ethylhexylic acid, is very interesting. In this instance the solidification points of all four esters are very low. There is no difference between trimethylol ethane and trimethylol propane. The glycerine ester has the lowest viscosity, the pentaerythritol, on the other hand, the highest viscosity and also the best viscosity-temperature relation.

If instead of 2-ethylhexylic acid, the carboxylic acid mixture is used which is obtained from the alcohols boiling at 200 to 250°, contained in the isobutyl oil, esters are obtained which are equivalent in their viscosity relations to the previous esters but which are not so good with respect to solidification point. The solidification point of the glycerine ester is worth noting. Such esters might be used in the lacquer industry as softeners, and in the electrical industry as switch oils. The effect of incomplete esterification of these polyalcohols on the viscosity-temperature relation is very interesting. These correlations are shown in

Fig. 11 (No. 57082)

It will be seen, both for trimethylol ethane and pentaerythritol, that the viscosity increases and the viscosity-temperature relation decreases in proportion to the number of free hydroxyl groups in the ester. This is understandable because free hydroxyl groups induce a strong association in the ester molecule. All alcohols are, as we know, highly associated. It is interesting that this association, as confirmed by experiments of Prof. Dr. Wolff in Halle and his co-workers made at my suggestion, indicates that this formation of super-molecules proceeds in an absolutely uniform manner. In the entire mass there are equal numbers of single, double, triple, quadruple, up to 12-fold molecules.

Fig. 12 (No. 57083)

covers the investigation of esters of bivalent glycols. Of these bivalent glycols, ethylene glycol, 1,4-butylene glycol, 1,6-hexylene glycol, 1,6-methyl-hexylene glycol and dimethylol propane were investigated. It will be seen that in the esters of straight chain glycols with n-octylic acid a rise in viscosity and a decrease, i.e. improvement, of the m-value occurs with increasing molecular weight. The lowering of the solidification point in the cases of methyl-hexylene glycol and dimethylol

propane is interesting. Here again the influence of the methyl group is apparent, as we had already found for the hydrocarbon hexadecane. The solidification point is very good if iso-octylic acid or lauric carboxylic acid is used instead of n-octylic acid. However, with these ramified acids the viscosity-temperature relation is somewhat poorer.

Fig. 13 (No. 57098)

covers an investigation of esters of adipic and methyl adipic acids. A comparison of the n-octanol and i-octanol esters is of interest. The latter has an excellent cold test due to the influence of the ethyl side chain. The effect of the methyl group is quite similar as shown by a comparison of cyclohexanol and methylcyclohexanol. These two esters, compared with the octanol ester, have a higher viscosity and a poorer viscosity-temperature relation. This is in good agreement with the investigations on hydrocarbons, as you may recall from the tables on the cyclization of the carbon chain of C₂₈ hydrocarbons (Fig. 9). The corresponding esters of methyl adipic acid differ insignificantly in their viscosity-temperature relation from those of adipic acid, although their cold tests are somewhat better. The cyclohexanol ester of methyl adipic acid is of particular technical interest. It is used as a watch lubricant because of its property of not running on a metallic surface but forming coherent drops. It also finds application as an additive in our aircraft hydraulic oil.

Fig. 14 (No. 57092)

Here the influence of the methyl group of dicarboxylic acid is illustrated more in detail. We may compare n-octanol and n-dodecanol esters of α - and β -methyladipic acid with those of adipic acid. It is striking that the esters of α -methyladipic acid are always somewhat poorer in their viscosity-temperature relation than those

of β -methyladipic acid. This is a good opportunity to show how important the position of a side chain in the molecule really is. If we esterify the acid with branched alcohols, such as our Leuna alcohols or the Oxo alcohols which are obtained by oxidizing di-isobutylene, esters are obtained with a very excellent cold test. In this instance the esters of sebacic acid are quite remarkable since they have a good cold test in addition to an excellent viscosity-temperature relation and are, therefore, better than those of adipic acid. The ester of β -methyladipic acid with Leuna alcohol finds application in the manufacture of cold resistant motor oils and journal oils and some have been found suitable for softening Igelit.

Fig. 15 (No. 57096)

shows the effect of an increase in the size of the molecule on the viscosity-temperature relation. In this instance multivalent alcohols were esterified, in the first place with normal octylic acid and then with the long-chain semi-ester of adipic acid and the Leuna 140-180° alcohol fraction, comprising essentially C₆ and C₇ alcohols. It will be seen that the latter esters are much more viscous and are even better in their viscosity-temperature relation than esters of normal octylic acid. Since the branched Leuna alcohol is contained in the semi-ester, the cold test as indicated by the solidification point of this ester is excellent. The lubricating power of such esters is also very good. They have found practical application as cutting oils. A straight-chain increase of the size of the molecule can also be accomplished by ethoxylizing an alcohol.

Fig. 16 (No. 57095)

again shows the result of the investigation^{of} this subject. An i-C₉ alcohol mixture obtained by oxidizing di-isobutylene was first used as the alcohol. The ethoxylation was performed by introducing ethylene oxide into the anhydrous alcohols. It

is important for all alcohol molecules to absorb ethylene oxide uniformly. This uniform distribution of the ethylene oxide is only possible when boron fluoride is used as catalyst. In Fig. 16 it can be seen that the viscosity increases and the viscosity-temperature relation is improved by increasing the ethylene oxide content. On the other hand, the cold test deteriorates as the ethylene oxide is increased. A comparison of Leuna alcohol esters of adipic, methyladipic and sebacic acid treated with 2 mol. ethylene oxide is very interesting. The cold test of these three esters is absolutely identical, the viscosity increases and the viscosity-temperature relation improves in the order: adipic, methyladipic and sebacic acid. Here again the sebacic acid ester is the best. Unfortunately these esters have the disadvantage of being rather immiscible with certain hydrocarbon oils, especially when the esters contain much ethylene oxide. More than one mole of ethylene oxide should not be added; with 2 moles of ethylene oxide the miscibility with hydrocarbon oils at room temperature is lost. At higher temperatures, e. g. 80° , this ester is completely miscible. When still more moles of oxide are added, the miscibility at elevated temperature is also lost.

—After having learned the correlation of the constitution of the esters and their viscosity relations, we attempted to investigate the relation between constitution and lubricating power. In this case we made use of equipment developed by the Technical Testing Division in Oppau, the so-called Chain Machine. The apparatus is shown in

Fig. 17 (No. 1105)

and consists of a weighted chain which is pressed from below around half the circumference of a roll. The chain and roll are immersed in the oil to be tested, which may be heated electrically. By turning the roll the chain is more or less carried along in the direction of the rotation according to the lubricating effect of the oil which is correspondingly recorded on a scale. Since only a point-to-point contact prevails between the links of the chain and the roll, and the speed of rev-

olution is kept very low, the apparatus operates within the range of boundary lubrication.

In Fig. 18 (No. 57 134)

a few results are given of determinations made with this apparatus. Curves 1, 2 and 3 give data on esters of adipic acid with the straight-chain alcohols butanol, octanol, and dodecanol. It will be seen that with increasing molecular weight the coefficient of friction decreases and the friction-temperature ratio constantly improves. If the adipic acid in these esters is replaced with methyladipic acid, Esters 4 and 5, we see that the coefficient of friction of the methyladipic acid ester is always higher than that of the corresponding adipic acid ester. This influence of the methyl group is confirmed in

Fig. 19 (No. 57133)

from a comparison of Esters 2 and 6, and 6 and 7. The right side of the chart is interesting as it shows the wear caused by the ester of a hard metal disc pressed against a steel plate. Here we see that the ester which has the highest coefficient of friction value produces the lowest wear.

The same result is shown in

Fig. 20 (No. 57131)

Here the esters of bivalent glycols are compared. The ester with the longest carbon-chain has the lowest coefficient of friction, and again produces the highest wear.

Fig. 21 (57132)

shows the sharp decrease in friction with constant molecular weight of the ester. Let us compare No. 25 with 11, 12, 13, and 16. The temperature coefficient consistently improves. In Ester 16 a slight decrease in frictional coefficient with

increasing temperature is noted. A comparison of 11 and 12 is also worth noting: The branched chain acid has the higher frictional coefficient and the greater friction-temperature coefficient. It is also interesting to note that the frictional coefficient, is only slightly decreased by incomplete esterification while the temperature coefficient is not influenced at all; this is illustrated by comparing 17 with 13. In the wear tests the order of the esters is opposite to that of the friction values. In esters of still higher molecular weight, shown in

Fig. 22 (No. 57130)

the decrease in the frictional coefficient and the flattening of the viscosity-temperature curve with increasing mol. wt. are again confirmed.

This interesting mutual behavior between lubricating power, as characterized by the frictional coefficient, and wear, is due to the force with which the molecules are retained on the surface. The work which is exerted in order to tear off liquid from 1 cm^2 of the interface area is called the work of adhesion. It may be determined by measuring the interfacial tension and the surface tension of the two interfacial couples. The equation of Duprès holds in this case: $H = \sigma_1 + \sigma_2 - \gamma_{12}$

At my suggestion a number of substances were investigated by Prof. Dr. Wolff with respect to their work of adhesion. A few results of these investigations are shown in

Fig. 23 (No. 57101)

Of the hydrocarbons, benzene, which adheres much more strongly to mercury than its hydrogenation product, cyclohexane, is of interest. In the alcohol series, an increase in the work of adhesion is noted with increasing length of the carbon chain. It is remarkable that branching of the carbon chain causes a decrease in the work

of adhesion. In acids the work of adhesion is entirely independent of molecular size. This may be due to the fact that molecular association prevails in all acids. Formation of super-molecules of more than two units occurs only in formic acid. In esters we find, exactly as in alcohols, an increase in the work of adhesion with increasing mol. wt. of the alcohol. In this instance it is worth noting that branching of the carbon chain in the alcohol produces an evident increase in the work of adhesion. The reason for this difference in behavior in comparison to pure alcohols is probably due to the manner in which the molecules are arranged at the interface. Here we have two possibilities: the molecules are either placed vertically with their carbon chains perpendicular to the interface, or they are arranged tangentially. The preferred arrangement of individual compounds depends in the first place on the steric position of the dipole groups in the molecule and, in the second place on the position and size of the permanent dipoles within the group.

The work of adhesion is evidently not only dependent on the lubricant, but also on the other member of the boundary surface.

Fig. 24 (No. 57087)

shows the differences between the work of adhesion at an aqueous and a metallic boundary surface. We note the great differences between water and mercury. The compounds adhere to mercury, on the average, 2-3 times better than to water. The adhesiveness may be calculated from the work of adhesion.

Fig. 25 (No. 57085)

shows the corresponding values for hydrocarbons, alcohols and acids. An increase in adhesiveness can again be seen in hydrocarbons as their unsaturated character increases, in alcohols as the length of the carbon chain increases,

while in acids adhesiveness is independent of molecular size. These adhesiveness values which measure the force required to tear off an interface of 1 cm^2 cross-section represent the tensile strength within the liquid or metal. The latter is calculated from the interfacial tension. The rupturing force is $H_2 = 20$. The magnitude of this force for liquids is striking. To rupture a liquid organic acid the same or even a greater force is required than to rupture a metal, such as brass or iron. This fact obviously explains the inverse relation between the coefficient of friction and wear. The load carrying power of a layer of lubricant increases with the adhesiveness of the lubricant so that when the coefficient of friction is small the force required by each liquid molecule to tear off one metal atom from the surface must increase. In developing lubricants which are to give low wear we must consequently not select substances which have extremely high adhesiveness but must strive to approach an optimum. In order to reach this goal we must not direct our attention entirely to the dipole forces of the molecule but must rather consider the dispersion forces within the molecule, the causes of which lie in the specific quantum bond of the carbon chain.

The lubricant alone is not responsible for wear, but the other interfacial member, the metal, participates as well.

Fig. 26 (No. 1412)

shows the difference in wear of various metals for the same compound. A substance such as the polyether alcohol LK 2200 may be extremely wear-resistant to red brass, while the wear of soft metals may be so high that it can almost be said that the metal dissolves. A pure mineral oil, such as K 7, differs considerably with respect to various metals.

This variable behavior of oils toward different metals is evidently reflected in practical lubrication. If we consider in the next

Fig. 27 (No. 1180)

the different lubricating conditions existing in a journal bearing, we shall find that the chemical constitution of the lubricant is important chiefly within the range in which the speed of revolution is low and the load correspondingly high. This is the range of partial or boundary lubrication.

In the following

Figs. 28 (No. 57156), 29 (No. 57157), and 30 (No. 57158)

is illustrated the behavior of different bearing metals with the same oil during boundary lubrication. The experiments were made by Prof. Dr. Heidebroeck in Dresden. It will be seen how for the same load the point of transition from complete lubrication to boundary lubrication changes in accordance with the nature of the bearing material. In this instance the boundary forces penetrate thicker layers of the liquid. It is probable that any orientation in the deeper liquid layers must start from the boundary surface as is shown in

Fig. 31 (No. 57159)

from a comparison of the effect of two different bearings, using the same oil. It will be seen that different oil pressures must be applied in order to force a definite amount of oil to flow through a given bearing clearance per unit of time, depending upon the nature of the bearing material.

Aside from these forces which emanate from the boundary surface, lubrication is also influenced by other factors induced by the structure of the liquid.

Fig. 32 (No. 57097)

shows a few determinations made by Prof. Dr. Heidebroeck on a gear testing machine. This machine consists of two carefully fitted gears in the bearings of which a

quartz pressure crystal has been installed, which permits the oscillographic determination of the slightest vibrations emanating from the irregularities of the gear teeth. In this machine the tooth surfaces are lubricated with an accurately weighed quantity of lubricant (measured to 1 cc) and the time elapsing until the lubricating layer fails is determined from the appearance of rust spots on the gear teeth, due to so-called frictional oxidation. Simultaneously the vibration of the gears recorded oscillographically and the amplitude of these oscillations are measured. In this figure seven oils varying with respect to their viscosity and chemical structure were investigated. It will be seen that the life, that is, the time until frictional oxidation sets in, differs widely and has no connection with viscosity. The same applies to the oscillation amplitude for Oils 13, 14 and 15. These three oils are esters: No. 13 is a polybutylene glycol; No. 14 is a polyester of 2 moles of trimethylol ethane and 1 mole adipic acid esterified with Leuna carboxylic acid; No. 15 is the same polyester, except that Soap fatty acids from the Oppau paraffin oxidation have been used instead of Leuna carboxylic acid. We see that 1 cc of Ester No. 14 has an extremely long lubricating life while Ester No. 15 is characterized by a very small amplitude in its vibration oscillogram. This ester consequently causes the gear machine to run very quietly. Oils 5, 6 and 7 are high-molecular ethylene polymerizates with considerably higher viscosities than Ester No. 15 but, nevertheless, the oscillation amplitudes of these highly viscous oils are twice as high as those of the much less viscous Ester No. 15. The viscosity, and hence the molecular size, is consequently a matter of no significance for quiet operation of the machine. The molecular structure alone is significant. Oil No. 15 is a voltolized fatty oil whose lubricating properties for plain bearing are much praised. For gear lubrication it has no advantage.

Fig. 33 (No. 57094)

shows oscillograms of the above oils. The steady, quiet run produced by Ester No. 15

is in distinct contrast to the irregular run of the seven times more viscous vulcolized fatty oil No. 12.

We have succeeded in so controlling the ethylene polymerization that polymerizates are now obtainable which behave as Ester No. 15, damping oscillations and deadening sound.

Fig. 34 (No. 57161)

shows the results of sound measurements made by Krupp with a similar oil.

A matter of great interest is the effect of damping oils of this type on the friction in a journal bearing. The same oil which was investigated by Krupp was also studied by Dr. Heidebroeck in a journal bearing.

Fig. 35 (No. 57154)

shows the results of this investigation. Five different oils were tested. Our damping oil is Oil K-I. Oil K II is also an ethylene polymerizate of low viscosity. The entirely different behavior of Oil K I which maintains the complete lubrication even at very low speeds is apparent. The lower portion of the chart shows that blends of the oils K I and K II can be made which prevent boundary lubrication even at low speeds.

Fig. 36 (No. 57155)

shows the effect of temperature on the friction in a journal bearing. With increasing temperature the friction decreases because the viscosity is lowered. It is noteworthy (shown in the chart) that Oil K I does not produce boundary friction even at low speeds.

The effect of temperature on friction and on lubrication has brought up a number of technical problems in the last two years of the war. The first of these problems was the lubrication of armament at the very low temperatures encountered

by the "Luftwaffe" (Air Forces) at high altitudes.

Fig. 37 (No. 51026)

shows the influence of viscosity on the operation of an aircraft machine-gun at very low temperatures. The problem in this case was to produce thin oils which at -60° allowed perfect starting of the machine gun and a full number of shots. As will be seen from this chart we succeeded in doing this with Oils 494 and 495. For this purpose we had to look for compounds of very low viscosity which were capable of withstanding the high pressures at the different bearing points.

Fig. 38 (No. 51027)

shows the relation between chemical constitution of various compounds and their viscosity as well as their lubricating properties in machine guns. The latter is characterized, in the first place by the time required to fire 50 shots and in the second place by the number of shots that can be fired with a single lubrication of the gun. It is obvious that rate of firing and total number of shots differ markedly, depending on the structure of the particular compounds. The last compound, No. 442, solved the problem. This compound was obtained by converting the xanthate of amyl alcohol with sulfur monochloride. The product is a golden-yellow oil containing about 50% of sulfur and may actually be said to be liquefied sulfur. It has not only rendered valuable service in the field of lubrication but has also found application in lacquers. With respect to rubber lacquers, the so-called "Pervinan" lacquers, the problem was to produce liquid, vulcanizable, brushing lacquers. This compound, called "Mesulfol", is soluble in all lacquer solvents and is decomposed on baking the lacquer, with separation of very reactive sulfur which is then readily capable of vulcanizing the Pervinan. In this connection it should be mentioned that Dr. Giesen had a very fortunate idea in combining a Lacquer Laboratory with the

Lubricant Laboratory. Both fields include applied surface research and the investigation of the structure and behavior of liquids.

The effect of "Mesulfol" on the lubrication of machine guns is shown in

Fig. 39 (No. 51025).

The variable effect of "Mesulfol" in esters and in hydrocarbon oils should be noted. Let us compare 463 with 469. In order to accomplish the same effect on firing, the hydrocarbon oil requires a higher percentage of sulfur, as will be seen from a comparison of 469 with 495. In practice we therefore had to make a 50/50 blend of ester and hydrocarbon oil. This product has been used more and more by the Air Force since January 1941. We started with a monthly supply of 5 tons and have now reached 50 tons per month (50 moto).

Another field of application of our esters is the Railroads. In this case cold-resistant journal oils had to be produced for the East, e. g. journal oils which at -40° will easily saturate the journal boxes of freight cars since the satisfactory lubrication of journals and the rapid disposal of cars in freight yards depends on the good absorptive power of the lubricating pads which are made of artificial silk. When freight cars do not run the standard mileage in winter the overhauling of the cars requires a large fleet of locomotives which is not available for that purpose. The journal box oils which were previously used by the Railroads consisted of waste products from oil refineries.

Fig. 40 (No. 50764)

shows the composition of mineral journal box oils. It will be seen that they only contain 50-60% of the proper hydrocarbon lubricants, the remainder being undesirable foreign matter of variable chemical composition.

Fig. 41 (No. 50765)

shows the viscosity-temperature relation of these oils. The great differences in viscosities at -28 and -30° can be seen. On comparing blends of these oils, such as 6 and 7, or 8, 9 and 10 we see that the oils mutually influence one another to a considerable extent. We first attempted to dilute the oils by adding an ester and thus improve their cold-resistance. In this manner we succeeded in lowering greatly the viscosities at low temperatures, but the absorptive power in the journal box could not be improved to the desired extent as may be seen from

Fig. 42 (No. 54694)

In this case the addition of gas oil is better, particularly at -10° . The effect of the gas oil is due to the fact that this oil is capable of dissolving paraffin and other extraneous matter, such as resins and asphalt, while the ester is incapable of doing so. Within the temperature range in which the ester is miscible with hydrocarbons and other materials its capillary action is apparent, as is indicated by increased absorptive power at $+50^{\circ}$. We solved the problem by making a blend of 40 parts of adipic acid ester with about 60 parts of a synthetic hydrocarbon oil. This blend is perfectly homogeneous even at low temperatures as may be seen from the straight line viscosity-temperature curve of our Y-Journal oil in

Fig. 43 (No. 57100)

in comparison to ordinary journal oil. The necessary hydrocarbon component is obtained by polymerization of hydrocarbons obtained by decomposing the aluminum chloride sludge from SS 906 oil production. On the basis of a decision of Reichsminister Dr. Dörpmüller of March last year this oil is to be used until 1945 by the entire fleet of freight cars of the German Railroads. This change will result in a saving of petroleum products to the German Petroleum Industry of

about 50,000 Jato (tons per yr.) which can be applied to other uses.

In conclusion I come to the most important field of application of the synthetic work, engine lubrication, which has been the starting point for all our work.

Fig. 44 (No. 46841)

shows the effect of a 25% addition of ester to a hydrocarbon aviation oil. In the first place an increase is seen in the overhaul time through the addition of the ester as well as a great reduction in the wear of piston rings. As shown in

Fig. 45 (No. 45115)

an addition of ester also improves the engine overhaul time of synthetic oil No. SS 904. It is important, however, that an inhibitor be included even when the ester has been added, as illustrated by a comparison of Experiments 475 and 580. The importance of adding an inhibitor was discovered by us about 8 years ago in engine tests. The action of these compounds only recently has been somewhat better understood.

Fig. 46 (No. 57099)

shows the action of oxygen on our synthetic oil SS 906. These experiments started by Dr. Fiedler and at present continued by Dr. Maichle show that SS 906 oil absorbs oxygen and forms peroxides. With increasing peroxide content the iodine number decreases, the acid number increases and the viscosity rises considerably. The latter condition is very undesirable when the purpose is to develop a cold-resistant oil; for a cold-resistant oil must not change its viscosity in use. When such an increase in viscosity takes place in use (by oxidation) the cold-resistance is also lost. We therefore have to look for compounds that reduce or prevent thickening, i. e. the formation of peroxides. We have found such a substance in silver,

which, as is shown in

Fig. 47 (No. 57093),

reduces the absorption of oxygen very markedly and consequently the formation of peroxides, although this may not be entirely avoided. We use silver in the form of a salt, di-isobutylene phenol sulfide. These investigations have shown that all organic silver compounds do not have the same activity.

Fig. 48 (No. 57091)

illustrates the relation between increase in viscosity by oxidation and inhibitor content. It will be seen that an addition of 0.2% reduces the increase in viscosity about one half. In engine tests of these inhibitors the running time was increased 100% and the formation of varnish on the piston surfaces, considerably reduced at the same time. Simultaneously, the increase in viscosity of the oil in use was largely reduced. A particularly important result of these engine tests is the reduced varnish formation; these varnishes are known to be highly oxidized products. We may now assume that the primary cause for their formation is caused by peroxides. In practice the reduction in the formation of varnish means that engine overhaul can be reduced and a saving thus made in ground personnel.

One of the objects of lubricating oil research must be to develop oils which, on the whole, do not form deposits on any of the engine parts and, consequently, make the lubricant one of the actual elements of construction of the engine itself. Inhibitor research within the domain of organic catalysts will undoubtedly yield results of great significance to the war effort.

Fig. 49 (No. 52270)

shows the present state of the development of a low cold-test aviation engine oil. The goal of this development must be to produce an oil which at -40° does not have

a viscosity of more than 2000 E^o.

Fig. 50 (No. 57162)

illustrates the present state of development of automobile oils. An SS Division in the East was able to operate without difficulty in cold weather by using oils prepared here last winter. The problem which the automobile industry places before us and the solution of which we are striving to obtain is an oil with a maximum viscosity of about 1000 E^o at -40^o.

Fig. 51 (No. 42614)

shows the relation between the viscosity-temperature curve and adhesiveness. Adhesiveness is a measure of the force which must be exerted to set in motion a shaft submerged in cold oil. Adhesiveness is measured in an apparatus developed by the Technical Division of Oppau and generally adopted by the "Luftwaffe". The chart shows how adhesiveness greatly increases with increasing viscosity. If the low adhesiveness of the low viscosity oils is to be attained by highly viscous oils, the viscosity-temperature relation, characterized by the bearing factor "m", must be greatly improved. "m"-Values of less than 3.0 must be reached. At present, values of 3.2 have been attained.

Fig. 52 (No. 57160)

shows the adhesiveness of our present low cold-test auto oil. It will be seen that this oil has the same adhesiveness as the best Army winter mineral oil at -35^o. We have thus nearly reached the goal we have set.

During the war all these development problems have been rendered very difficult because of the raw materials which are needed for solving them have become increasingly scarce. We must therefore direct our synthetic research work toward solving the raw material problem. Quite recently this has been done by resuming the copolymerization

studies which were started in 1930. At that time we were able to show that a petroleum lubricating oil fraction, from which paraffin, asphalt, and resins had been removed, could be improved by mixing it with $AlCl_3$ -containing crude cracked paraffin polymerizates. The reactive hydrocarbons present in the mineral oil react with the cracked paraffin polymerizates causing them to be alkylated, polymerized and isomerized, and a mixed polymerizate is obtained which, as shown in

Fig. 53 (No. 45174)

is superior in automotive properties to a purely physical mixture of synthetic products and mineral oil raffinate. During the last year these experiments have culminated in polymerization of ethylene with the same good results, and plans are being made for the construction of a refinery in Moosbierbaum which will integrate the refining of natural products and the production of synthetic oils. In this way the process developed and patented in 1930 will finally find a practical application. We hope that in building this refinery on the Danube, beside a union of natural and synthetic products in the lubricant field, motor fuels will also be included in order to utilize natural products in a more complete manner.

Fig. 54 (No. 57173),

the last chart of this series, gives a brief synopsis of the effect lubricant research has had on production in our Organic Division. In this chart it will be seen that all products, except for two compounds, of our Division have been utilized in the lubricants field.

The "playful ways" have led us from the "deceptive moods" to purposeful research on lubricants. Let us hope that for the good of our Vaterland our present research and development work will be continued, because it is only on the basis of such work that we shall be able to solve many war problems.

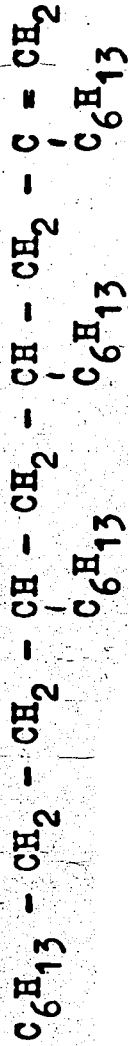
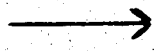
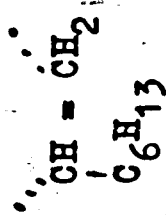
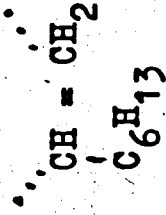
O l e f i n

V i s k o s i t ä t

	Ausbeute	38°	99°	V. J.
C7 $\text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{CH} = \text{CH}_2$	85%	34,4	2,91	99
$\text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{CH} = \text{CH} - \text{CH}_2 - \text{CH}_3$	45%	5,60	1,42	24
C8 $\text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{CH} = \text{CH}_2$	70%	38,70	3,56	114
$\text{CH}_3 - \text{CH}(\text{CH}_3) - \text{CH}_2 - \text{CH}_2 - \text{CH} = \text{CH}_2$	85%	387,0	13,20	98
$\text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{C}(\text{CH}_3) = \text{CH}_2$	38%	6,16	1,42	14

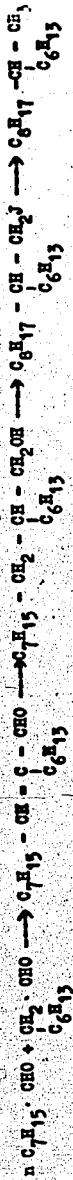
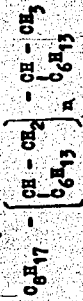
42037
J.A. Nr. 27

Polymerisationsschema von n - Octylen

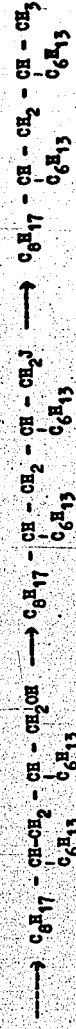


45106

Reaktionschema der Synthese von K₁ der allgemeinen Formel:



C₁₆H₃₄



C₂₄H₅₀



C₄₈H₉₈

45113.

Substanz (Name)	Molgew.	Viskosität in cSt bei °C					Sch.
		20	30	50	99	Y.P.	
1 C ₁₆ H ₃₄ 226 n C ₁₆ H ₃₄ - CH ₂ -CH ₃ C ₆ H ₁₃	0,7733	4,20	2,92	2,30	1,28	0,1	-
2 C ₂₄ H ₅₀ 336 n C ₂₄ H ₅₀ - CH ₂ -CH ₂ -CH ₂ -CH ₃ C ₆ H ₁₃	0,8000	15,8	8,60	6,14	2,31	1,14	123
3 C ₃₂ H ₆₆ 454 n C ₃₂ H ₆₆ - CH ₂ -CH ₂ -CH ₂ -CH ₂ -CH ₃ C ₆ H ₁₃	0,8115	38,56	18,54	12,1	3,74	1,42	118
4 C ₄₀ H ₈₂ 562 n C ₄₀ H ₈₂ - CH ₂ -CH ₂ -CH ₂ -CH ₂ -CH ₂ -CH ₃ C ₆ H ₁₃	0,8196	72,43	31,9	20,8	5,80	1,40	136
5 C ₄₈ H ₉₈ 674 n C ₄₈ H ₉₈ - CH ₂ -CH ₂ -CH ₂ -CH ₂ -CH ₂ -CH ₂ -CH ₃ C ₆ H ₁₃	0,8225	114,4	49,14	29,3	7,45	1,48	124
6 C ₅₆ H ₁₁₀ 782 n C ₅₆ H ₁₁₀ - CH ₂ -CH ₂ -CH ₂ -CH ₂ -CH ₂ -CH ₂ -CH ₂ -CH ₃ C ₆ H ₁₃	0,8133	164,12	71,46	41,8	9,74	1,36	134
7 C ₆₄ H ₁₃₀ 898 n C ₆₄ H ₁₃₀ - CH ₂ -CH ₂ -CH ₂ -CH ₂ -CH ₂ -CH ₂ -CH ₂ -CH ₂ -CH ₃ C ₆ H ₁₃	0,8203	221,2	96,8	52	11,10	1,42	133
8 C ₇₂ H ₁₄₂ 1014 n C ₇₂ H ₁₄₂ - CH ₂ -CH ₂ -CH ₂ -CH ₂ -CH ₂ -CH ₂ -CH ₂ -CH ₂ -CH ₂ -CH ₃ C ₆ H ₁₃	0,8298	253,9	101	60	13,14	1,41	127

57088

Summen- formel Mol- Gew.	Spez. Gew. 20° C	Viskosität in est bei ° C				V.I.	Schmelz- punkt ° C
		20	38	50	99		
1 $C_{32}H_{66}$ 450	$n\ C_{8}H_{17} - \underset{C_6H_{13}}{CH} - CH_2 - \underset{C_6H_{13}}{CH} - CH_2 - CH - CH_3$ C_6H_{13}	0,8115	16,50	12,1	3,74	1,42	118 ca -80
2) $C_{32}H_{66}$ 450	$n\ C_{8}H_{17} - \underset{C_6H_{13}}{CH} - CH_2 - CH_2 - \underset{C_6H_{13}}{CH} - CH - C_6H_{17}$ C_6H_{13}	0,8113	17,46	11,8	3,74	1,36	134 ca -20
3) $C_{32}H_{66}$ 450	$n\ C_{8}H_{17} - \underset{C_7H_{15}}{CH} - \underset{C_7H_{15}}{CH} - C_6H_{17}$	0,8140	17,55	12,3	3,89	1,26	149 ca -60
4 $C_{48}H_{98}$ 674	$n\ C_{8}H_{17} - \underset{C_6H_{13}}{CH} - CH_2 - \underset{C_6H_{13}}{CH} - CH_2 - \underset{C_6H_{13}}{CH} - CH_2 - \underset{C_6H_{13}}{CH} - CH_3$ C_6H_{13}	0,8225	45,14	29,3	7,49	1,48	124 ca -60
5 $C_{48}H_{98}$ 674	$n\ C_{8}H_{17} - \underset{C_6H_{13}}{CH} - CH_2 - \underset{C_6H_{13}}{CH} - CH_2 - \underset{C_6H_{13}}{CH} - CH_2 - \underset{C_6H_{13}}{CH} - CH_2 - \underset{C_6H_{13}}{CH} - CH_3$ C_6H_{13}	0,8261	50,8	32	8,10	1,44	133 ca -50
6 $C_{40}H_{98}$ 674	$n\ C_{12}H_{25} - \underset{C_{10}H_{21}}{CH} - CH_2 - \underset{C_{10}H_{21}}{CH} - CH_2 - \underset{C_{10}H_{21}}{CH} - CH_2 - \underset{C_{10}H_{21}}{CH} - CH_3$ $C_{10}H_{21}$	0,8082	(94)	(42,5)	7,66	1,23	147 fest bei 2... 17

57080

Haftarbeiten II verschiedener Stoffe an Quecksilber (bei 22° C)
nach Messungen v n K.L. Wolf und Dunkon, Halle

Stoff	Oberflächen- spannung (dyn/cm)	Grenzflächen- spannung (dyn/cm)	Haftarbeit (erg/cm ²)
<u>Kohlenwasserstoffe</u>			
Hexan	19,5	380	120
Cyclohexan	24,7	377	128
Benzol	28,6	366	143
<u>Alkohole</u>			
Methanol	22,5	384	119
Ethanol	22,4	382	120
n-Propanol	23,7	379	125
i-Propanol	23,7	384	117
n-Butanol	24,8	377	128
i-Butanol	20	384	116
n-Hexanol	26,4	372	134
n-Octanol	27	367	140
<u>Säuren</u>			
Essigsäure	37,4	393	124
Propionsäure	27,4	331	176
Buttersäure	26,5	333	174
n-Valeriansäure	26,6	335	172
n-Hexylsäure	27,4	333	174
n-Heptylsäure	28,1	334	174
n-Octylsäure	28,3	335	173
n-Nonylsäure	28,7	334	175
n-Decylsäure	29,9	332	178
<u>Ester</u>			
Methylacetat	24,9	388	117
Ethylacetat	25,8	384	120
n-Propylacetat	24,5	380	124
i-Propylacetat	23,1	369	134
n-Butylacetat	24,5	374	131
sek-Butylacetat	23,5	354	150
t-Butylacetat	22,8	355	148
n-Amylacetat	25,5	365	141
i-Amylacetat	24,8	345	160
n-Hexylacetat	26,3	365	141
n-Heptylacetat	27,1	347	150
n-Decylacetat	28,7	343	166
n-Dodecylacetat	29,1	341	168

57080

Dicht. bei 15°C	Mol- gew.	Chem. Formel	spez. Gew. 20°C	Viskosität in cSt bei °C			n _D ²⁰	V.I.	Schmelzpunkt
				20	30	50			
0,726	226	CH ₃ - (CH ₂) ₁₄ - CH ₃	0,7733	4,39	2,94	2,42	1,30	0,1	18
0,731	226	n C ₆ H ₁₇ - CH - C ₆ H ₁₃ CH ₃	0,7739	4,20	2,92	2,30	1,28	0,1	-30,4
0,734	226	n C ₆ H ₁₃ - CH - CH - C ₆ H ₁₃ CH ₃ CH ₃	0,7811	4,22	2,76	2,21	1,23	0,1	-6
0,734	226	n C ₄ H ₉ - CH - CH ₂ - CH - C ₄ H ₉ C ₂ H ₅ C ₂ H ₅	0,7823	3,70	2,55	2,09	1,10	0,06	na - 80
0,734	226	n C ₄ H ₉ - CH - CH ₂ - CH - CH ₂ - CH - CH ₃ C ₂ H ₅ C ₂ H ₅ C ₂ H ₅	0,7791	3,58	2,46	2,02	1,07	0,04	na - 4
0,735	330	CH ₃ - (CH ₂) ₂₂ - CH ₃	0,7746	(14,9)	(6,90)	(6,63)	2,81	(0,7)	(224)
0,750	336	n C ₆ H ₁₃ - CH - CH ₂ - CH ₂ - CH - C ₆ H ₁₃ C ₄ H ₉ C ₄ H ₉	0,8020	16,96	9,03	6,28	2,32	1,3	na - 1
0,750	336	n C ₅ H ₁₁ - CH - CH ₂ - CH ₂ - CH - C ₅ H ₁₁ n C ₅ H ₁₁ n C ₅ H ₁₁	0,8114	18,09	9,4	6,50	2,34	1,42	60
0,750	330	n C ₅ H ₁₁ - CH - CH ₂ - CH ₂ - CH - C ₅ H ₁₁ i C ₅ H ₁₁ i C ₅ H ₁₁	—	23,2	10,85	7,43	2,41	2,05	26
0,750	336	n C ₄ H ₉ - CH - CH ₂ - CH - CH ₂ - CH - C ₄ H ₉ C ₂ H ₅ C ₂ H ₅ C ₂ H ₅ C ₂ H ₅	0,8119	16,27	9,1	6,28	2,27	1,58	na - 6

7004

Konstitution und Schmelzpunkt.

Benzol	+ 5,5°
Toluol	- 95°
Äthylbenzol	- 94°
m-Xylol	- 54°
o-Xylol	- 29°
p-Xylol	+ 13°
 Cetane:	
$\text{CH}_3 - (\text{CH}_2)_{14} - \text{CH}_3$	+ 18°
$\text{CH}_3 - (\text{CH}_2)_7 - \underset{\text{CH}_3}{\text{CH}} - (\text{CH}_2)_5 - \text{CH}_3$	- 39°
$\text{CH}_3 - (\text{CH}_2)_5 - \underset{\text{CH}_3}{\text{CH}} - \underset{\text{CH}_3}{\text{CH}} - (\text{CH}_2)_5 - \text{CH}_3$	- 80°
$\text{CH}_3 - (\text{CH}_2)_3 - \underset{\text{C}_2\text{H}_5}{\text{CH}} - \text{CH}_2 - \text{CH}_2 - \underset{\text{C}_2\text{H}_5}{\text{CH}} - (\text{CH}_2)_5 - \text{CH}_3$	- 80°
$\text{CH}_3 - (\text{CH}_2)_3 - \underset{\text{C}_2\text{H}_5}{\text{CH}} - \text{CH}_2 - \underset{\text{C}_2\text{H}_5}{\text{CH}} - \text{CH}_2 - \underset{\text{C}_2\text{H}_5}{\text{CH}} - \text{CH}_3$	- 88°

Summen- Formel Gew.	Struktur- Formel	spez. Gew.	Viskosität in cSt Bei °C				n _D	Vf.	Vf.
			20	30	50	60			
C ₂₀ H ₄₀ 68,4		0,755	(17,2)	(17,8)	(9,3)	3,12	0,8	266	
C ₂₀ H ₃₆ 72,1		0,755	(37,3)	19,0	13,6	3,12	1,0	172	
C ₂₀ H ₃₄ 70,0		0,755	(97)	(41,4)	26,06	3,12	1,41	124	
C ₂₀ H ₃₂ 68,1		0,755	1050	262	140	3,43	2,01	62	
C ₂₀ H ₂₈ 64,0		-	60	30,2	10,7	3,62	1,60	116	
C ₂₀ H ₂₄ 60,0		0,755	(37,5)	(39,1)	27,6	4,18	2,00	50	
C ₂₀ H ₂₂ 58,0		0,755	(37,5)	(39,1)	27,6	4,18	2,00	50	

57081

Ester aus drei- und vierwertigen Alkoholen	spez. Gew. 20° C	Viskosität in cSt bei 0° C				Stockpunkt 0° C
		20	38	50	99	
$\begin{array}{c} \text{H}_2\text{OH} \\ \\ \text{CH}_2\text{OH} \\ \\ \text{CH}_2\text{OH} \\ \\ \text{CH}_3 - \text{C} \end{array}$	0,944	36,20	17,75	11,96	3,86	3,58 - 8
+ n-Octylsäure						
$\begin{array}{c} \text{CH}_2\text{OH} \\ \\ \text{CH}_2\text{OH} \\ \\ \text{CH}_2\text{OH} \\ \\ \text{CH}_3 - \text{CH}_2 - \text{C} \end{array}$	0,948	37,00	18,00	12,20	3,96	- 69
+ " " "						
$\begin{array}{c} \text{CH}_2\text{OH} \\ \\ \text{CH}_2\text{OH} \\ \\ \text{CH}_2\text{OH} \\ \\ \text{HC} - \text{CH}_2 - \text{CH} - \text{CH}_2\text{OH} \\ \\ \text{CH} \end{array}$	0,940	25,34	12,97	8,98	3,20	- 24
+ " " "						
$\begin{array}{c} \text{CH}_2\text{OH} \\ \\ \text{CH}_2\text{OH} \\ \\ \text{CH}_2\text{OH} \\ \\ \text{HC} - \text{CH}_2 - \text{C} \end{array}$	0,959	50,79	23,80	15,69	4,73	+ 7
+ " " "						
Trimethyloläethan	0,948	49,30	20,90	13,5	3,84	- 63
+ 1-Octylsäure =						
Trimethylolpropan	0,948	64,82	26,28	16,09	4,17	- 58
+ 2-Ethyl-hexylsäure						
Glycerin	0,952	40,27	17,39	11,10	3,21	- 66
+ " " "						
Pentaerythrit	0,966	143,7	52,01	29,94	6,37	- 45
+ " " "						
Trimethyloläethan	0,949	123,0	42,50	24,75	5,57	- 48
+ Leuna - Carbon-säuregemisch 200/250						
Trimethylolpropan	0,958	144,7	50,20	28,60	6,30	- 49
+ " " "						
Glycerin	0,954	94,4	34,0	20,7	4,93	- 60
+ " " "						
Pentaerythrit	0,961	453,0	117,2	63,5	10,46	- 31
						371180

Ester aus drei- und vierwertigen Alkoholen:
Unvollständige Veresterung

	spez. Gew. 20° C	Viskosität in cSt bei ° C				Stockpunkt ° C	
		20	36	50	99		
Trimethylacetat + 3 Mol 1-C ₁₃ -Säure	0,917	97,90	42,13	26,60	7,11	3,34	- 28
Trimethylacetat + 2 Mol " "	0,925	124,5	49,90	29,87	7,27	3,51	- 27
Trimethylacetat + 3 Mol - Leuocarbonsäure	0,949	123	42,50	24,8	5,57	3,96	- 48
" + 2 " "	0,962	193	59,50	32,40	6,57	4,01	- 44
" + 1 " "	0,982	427	105	51,5	7,80	4,34	- 33
Penterythrit + 4 Mol 1-C ₁₃ -Säure	0,929	179,50	71,10	42,80	10,00	3,27	- 28
" + 3 " "	0,934	213,2	81,20	48,50	10,40	3,33	- 27
" + 2 " "	0,951	339,0	114,9	64,50	11,70	3,50	- 26

57084

Ester aus zweiwertigen Glykolen		spez. Gew.	Viskosität in cSt bei °C				Spez. Licht	
			20° C	38	50	60		
HC - CH ₂ - CH ₂ - CH	+ n-Octylsäure	0,934	9,00	5,36	4,00	1,76	3,47	+ 18
HO - CH ₂ - CH ₂ - CH ₂ - CH ₂ - CH ₂ - CH	+ " " "	0,919	11,77	6,86	5,17	2,89	3,36	+ 17
HO - CH ₂ - CH ₂ - CH ₂ - CH ₂ - CH ₂ - CH ₂ - OH	+ " " "	0,920	17,40	8,40	6,76	3,60	3,33	+ 9
HO - CH ₂ - CH ₂ - CH ₂ - CH ₂ - CH ₂ - CH ₂ - OH	+ " " "	0,916	15,40	8,88	6,53	2,71	3,21	+ 10
$\begin{array}{c} \text{CH}_3 \quad \text{CH}_2 \text{ OH} \\ \diagdown \quad \diagup \\ \text{C} \quad \text{C} \\ \diagup \quad \diagdown \\ \text{CH}_3 \quad \text{CH}_2 \text{ OH} \end{array}$	+ " " "	0,920	14,50	8,10	5,87	2,36	3,00	+ 15
1,4-Butylenglykol	+ 1-Octylsäure	0,936	12,80	6,89	5,29	2,89	3,00	+ 17
1,6-Hexylenglykol	+ 2-Ethyl-hexylsäure	0,920	16,60	6,66	6,18	2,37	3,73	+ 12
1,6-Methyl-hexylenglykol	+ " " "	0,915	18,20	9,20	6,50	2,48	3,70	+ 11
Dimethylpropan	+ " " "	0,920	17,60	8,77	6,85	2,10	3,13	+ 10
1,6-Butylenglykol	+ Leuca - Carbon-säuremisch 200/250	0,910	22,00	11,90	8,2	2,64	3,64	+ 11
1,6-Hexylenglykol	+ " " "	0,926	23,53	12,20	8,60	2,20	3,45	+ 10
1,6-Methyl-hexylenglykol	+ " " "	0,922	29,60	14,80	9,87	2,60	3,63	+ 10
Dimethylpropan	+ " " "	0,930	30,90	15,40	10,00	2,01	3,00	+ 10

5703

Mater von Dicarbonsäuren		spez. Gew. 20° C	Viskosität in ost bei ° C					Stockpunkt ° C
			20	38	50	99	20:99	
Adipinsäure	+ n-Octanol	0,919	14,2	8,75	6,28	2,85	3,09	+ 10
"	+ n-Dodecanol	—	—	—	12,40	4,53	(3,05)	+ 36
α -Methyladipinsäure	+ n-Octanol	0,927	16,80	9,33	6,66	2,66	3,48	- 32
α - " "	+ n-Dodecanol	0,913	36,13	17,30	12,10	4,28	3,23	+ 16
β -Methyladipinsäure	+ n-Octanol	0,920	16,00	9,22	6,67	2,90	3,16	- 36
β - " "	+ n-Dodecanol	0,898	35,90	18,60	13,20	4,71	2,96	+ 10
Adipinsäure	+ Leunsalkohol 180/250	0,930	32,73	16,40	10,85	3,65	3,60	- 69
α -Methyladipinsäure	+ " "	0,933	49,20	20,90	13,40	4,07	3,71	- 60
β -Methyladipinsäure	+ " "	0,913	49,60	21,20	13,60	4,16	3,67	- 59
Dimethyladipinsäure	+ " "	0,932	58,70	24,20	15,50	4,29	3,85	- 57
Sebacinsäure	+ " "	0,916	44,10	20,70	13,90	4,45	3,48	- 70
Adipinsäure	+ 1 C ₂ -Oxalkohol aus Diäbutylen	0,918	24,00	12,70	8,70	3,22	3,43	- 72
β -Methyladipinsäure	+ " "	0,916	26,20	14,60	10,00	3,52	3,49	- 70
Methyladipinsäure	+ " "	0,916	30,73	15,00	10,41	3,53	3,59	- 68
Sebacinsäure	+ " "	0,911	38,33	19,50	13,40	4,71	3,20	- 60

57092

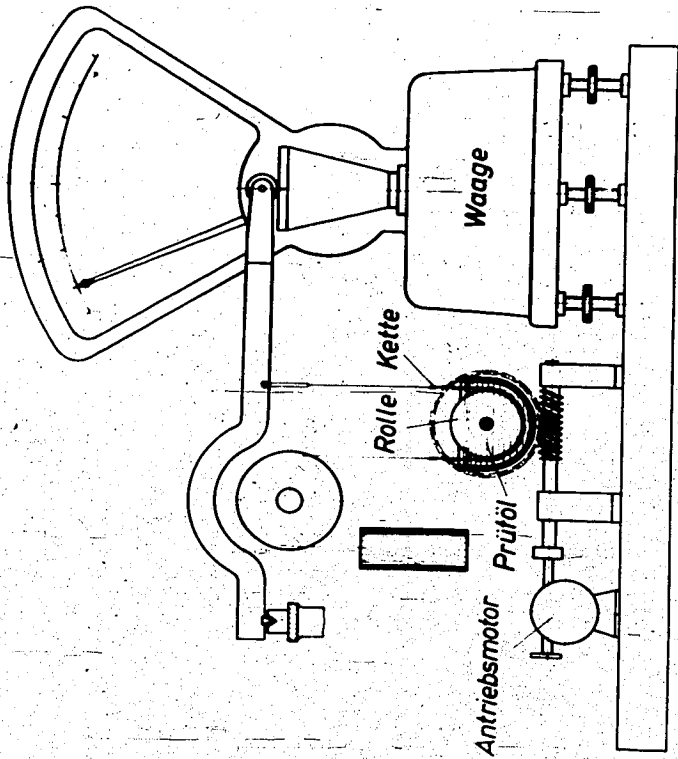
Ester aus mehrwertigen Alkoholen und dem Halboester (HE)
der Weinsäure: $\text{HOOC}-(\text{CH}_2)_4-\text{COOH}$

II = Leueralkohol 149/100

	Mol. Gew.	Viskosität in cSt bei °C				Stockpunkt °C
		20	30	50	99	
Aethylencykol	C ₈ O ₂	43,53	20,10	13,30	4,30	3,40 - 2
	C ₉ H ₁₄ O ₂	5,00	5,36	4,03	1,76	3,67 + 10
1,4-Butylenglykol	C ₁₀ O ₂	57,70	26,80	17,20	5,38	3,35 - 35
	C ₁₁ H ₁₈ O ₂	11,77	6,85	5,17	2,20	3,76 + 13
1,6-Hexylenglykol	C ₁₂ O ₂	64,20	29,53	19,80	6,14	3,16 - 10
	C ₁₃ H ₂₂ O ₂	12,40	8,40	6,26	2,62	3,33 + 9
1,7-Äthyl-hexylenglykol	C ₁₃ O ₂	87,30	40,20	25,30	7,23	3,23 - 60
	C ₁₄ H ₂₄ O ₂	15,40	8,18	6,53	2,71	3,31 - 20
Diacetyl-aceton	C ₁₀ O ₂	64,00	27,90	17,80	5,30	3,46 - 50
	C ₁₁ H ₁₈ O ₂	14,50	8,10	5,87	2,36	3,62 - 20
Triethyloläthan	C ₁₁ O ₂	226	81,25	47,67	16,75	3,30 - 51
	C ₁₂ H ₂₀ O ₂	36,20	17,75	11,96	3,86	3,88 -
Formantrith	C ₁₀ O ₂	482	177,7	101,1	19,50	3,04 - 11
	C ₁₁ H ₁₈ O ₂	56,70	23,60	15,69	6,73	3,50 +

57006

		spez. Gew. 20° C	Viskosität in cSt bei 0 C				Stoekpunkt 0 C	
			20	38	50	99		201,99
<u>Kolektivveresterung durch Aethoxylierung des</u> <u>anzwärtigen Alkohols: i C₂-Oxalkohol aus</u> <u>Diisobutylen</u>								
i C ₉ -Alkohol	+ 0 Mol C ₂ H ₄ C	0,918	24,00	12,70	8,70	3,21	3,43	< - 70
"	+ 1 " "	0,948	37,60	18,30	12,0	4,30	3,38	- 75
"	+ 2 " "	0,976	59,00	27,40	18,30	5,74	3,26	- 58
"	+ 4 " "	1,002	92,80	40,90	27,60	7,72	3,13	- 52
"	+ 6 " "	1,021	124,60	54,10	34,80	10,00	2,97	- 38
<u>i C₉-Alkohol</u> <u>+ 0 Mol C₂H₄O + Methyladipinsäure</u>								
"	+ 1 " "	0,916	28,20	14,50	10,00	3,52	3,49	- 70
"	+ 2 " "	0,950	46,00	21,90	14,70	4,73	3,40	- 60
"	+ 4 " "	0,974	67,10	29,07	19,50	6,16	3,24	- 55
"	+ 6 " "	0,998	98,00	42,30	27,10	8,31	3,06	- 50
"	+ 8 " "	1,038	180,0	75,20	47,01	12,50	2,92	- 16
<u>Leuns-Alkohol 180/240 + 2 Mol C₂H₄O + Adipinsäure</u>								
"	+ 2 " "	0,972	53,90	24,60	15,70	4,96	3,46	- 59
"	+ 4 " "	0,980	78,50	32,80	21,40	6,25	3,38	- 54
"	+ 6 " "	0,989	119,20	50,60	31,30	8,96	3,10	- 35
							57095	



57231

Techn. Prüfstand
 Oppau
 1105

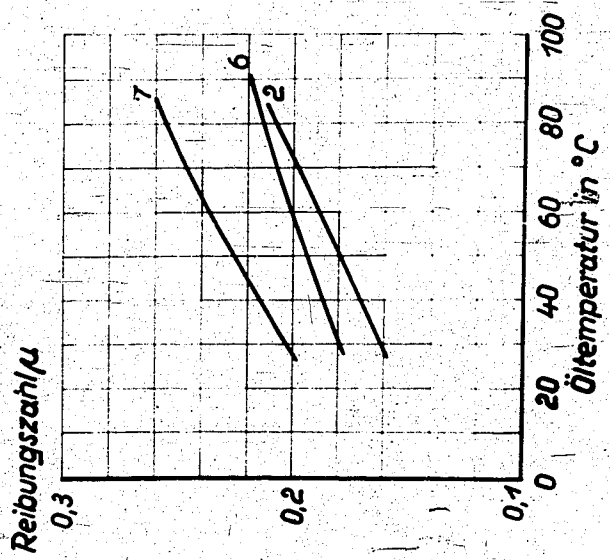
Reibungs-Prüfmaschine

IG

Lechvisstafon a. Rh.
 1941

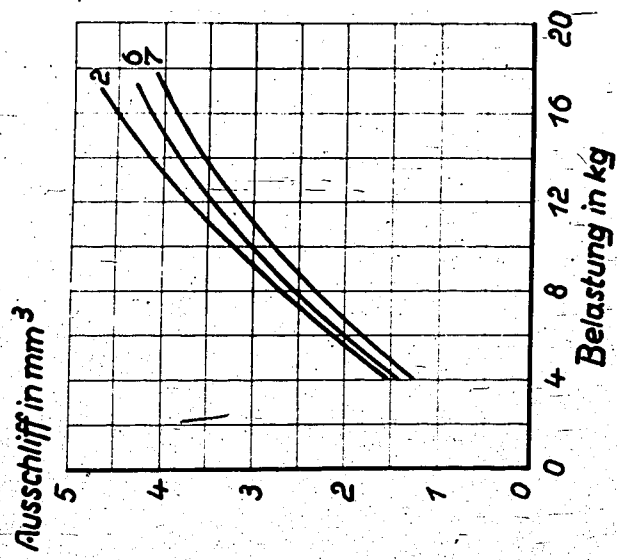
Versuche in der Kettenmaschine.

- 2 = Adipinsäure + n-C₈-Alkohol (350)
- 6 = " " + i-C₈-Alkohol (350)
- 7 = Methyladipinsäure + i-C₈-Alkohol (363)



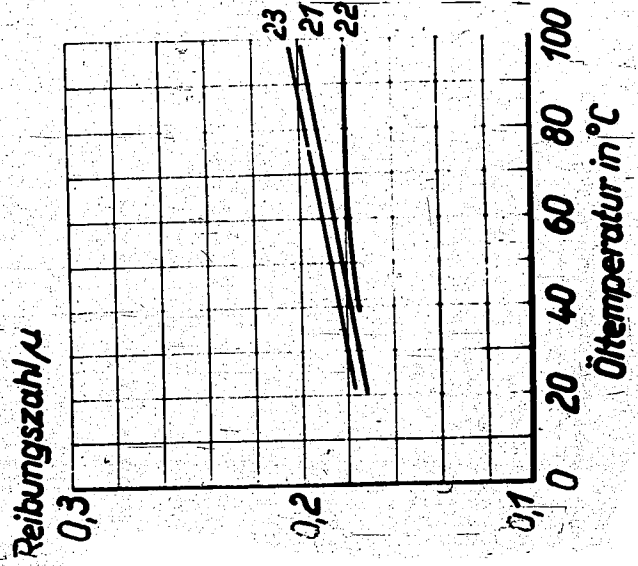
Verschleißversuche.

Scheibe aus Hartmetall gegen Stahl
 Versuchsdauer 10 Min.
 Ötemperatur 20°C



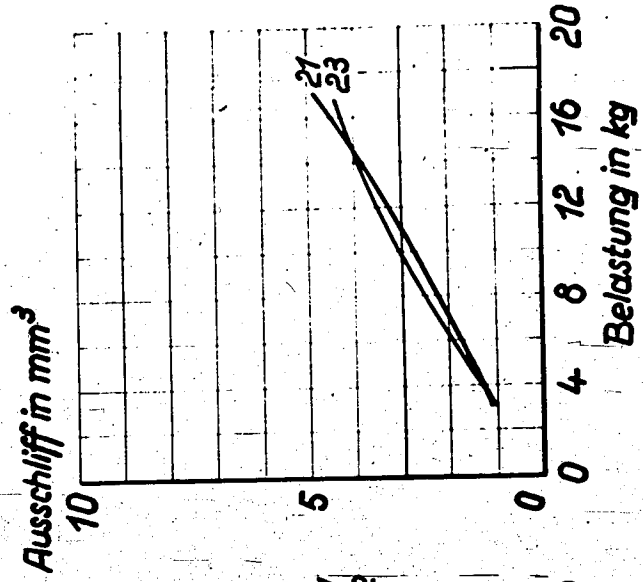
Versuche in der Kettenmaschine.

- 23 = Dimethylopropan + 2 Mol $\text{HOOC}-(\text{CH}_2)_4-\text{COOC}_8$
- 21 = 1,4 Butylenglykol + 2 Mol " "
- 22 = 1,6 Hexylenglykol + 2 Mol " "



Verschleißversuche.

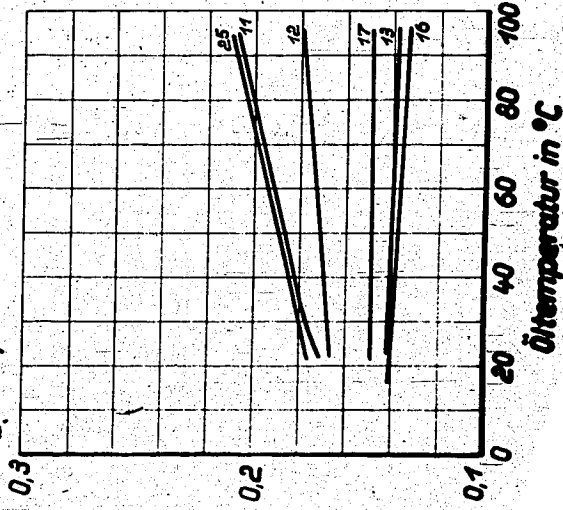
Scheibe aus Hartmetall gegen Stahl
 Versuchsdauer 10 Min.
 Öltemperatur 20°C



Versuche in der Kettenmaschine.

- 25 = Trimethyläthan + Leu α -Carbonsäure 200/250
- 11 = " " + i-C₈-Säure
- 12 = " " + Vorlauf-Fettsäure C₇-C₉
- 13 = " " + 3 Mol i-C₁₃-Säure
- 17 = " " + 2 " "
- 16 = Pentaerythrit + 4 " "

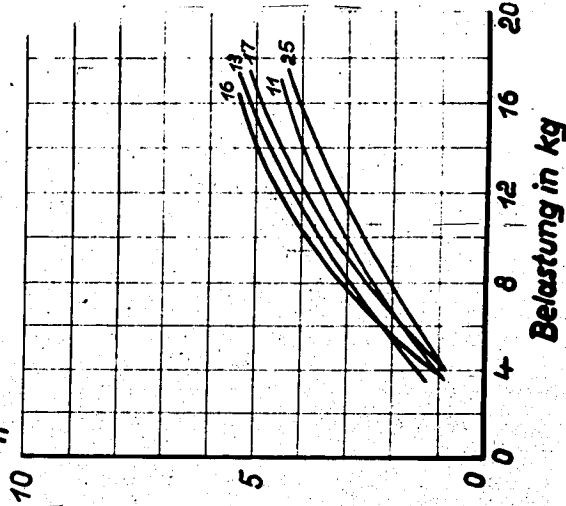
Reibungszahl μ



Verschleißversuche.

- Scheibe aus Hartmetall gegen Stahl
- Versuchsdauer 10 Min.
- Öltemperatur 20 °C

Ausschiff mm³



Versuche in der Kettenmaschine.

$iC_4-(OCH_2-CH_2)_x + \text{Methyladipinsäure}$

33: x = 0

34: x = 1

35: x = 2

36: x = 4

37: x = 6

$42 = iC_9 \text{ Alkohol} + 0 \text{ Mol } C_2H_4O + \text{Adipinsäure}$

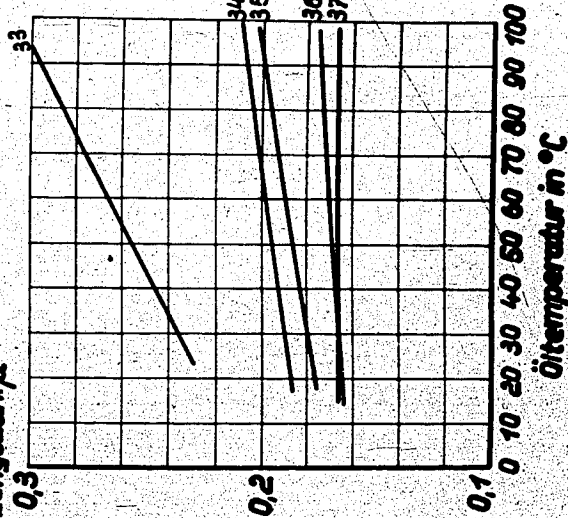
43 " " + 1 " " + " "

44 " " + 2 " " + " "

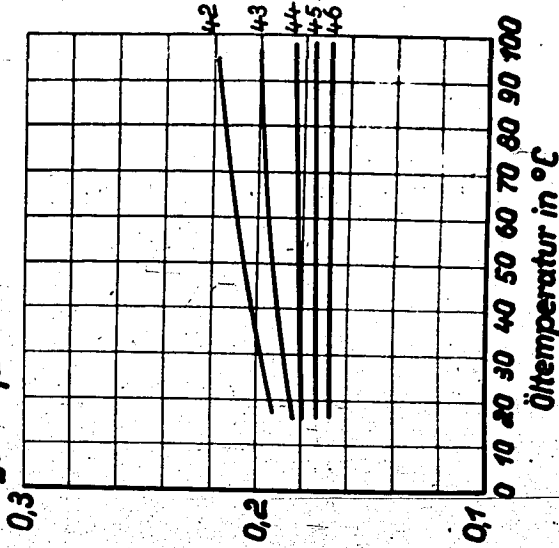
45 " " + 4 " " + " "

46 " " + 6 " " + " "

Reibungszahl μ

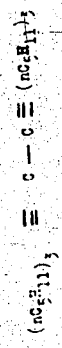
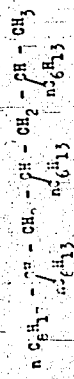
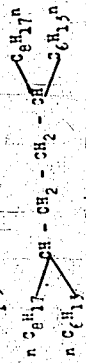
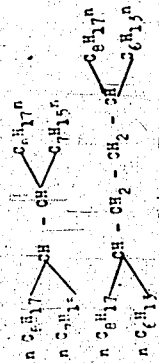
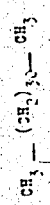


Reibungszahl μ



Mutterkollektionsnummer	spez. Gew. 20° C	Viskosität in cSt bei ° C				V.P.	V.I.	Schmelzpunkt ° C
		20	38	50	99			
1) C ₁₂ H ₂₂ 450	0,77675	(37)	(20,3)	(14,4)	2,96	0,86	187	+ 70,5
2) C ₁₂ H ₂₂ 450	0,8140	35,71	17,55	12,2	3,89	1,26	149	ca-80
3) C ₁₂ H ₂₂ 450	0,8133	36,12	17,46	11,8	3,74	1,37	134	ca-20
4) C ₁₂ H ₂₂ 450	0,8115	38,56	16,50	12,1	3,72	1,42	118	ca-80
5) C ₁₂ H ₂₂ 450	0,8204	78,56	31,6	19,5	4,90	1,96	86	ca-50

57101



Unterschiede der Haftarbeiten an wässrigen und
metallischen Grenzflächen nach Messungen von
K.L. Wolf, Halle

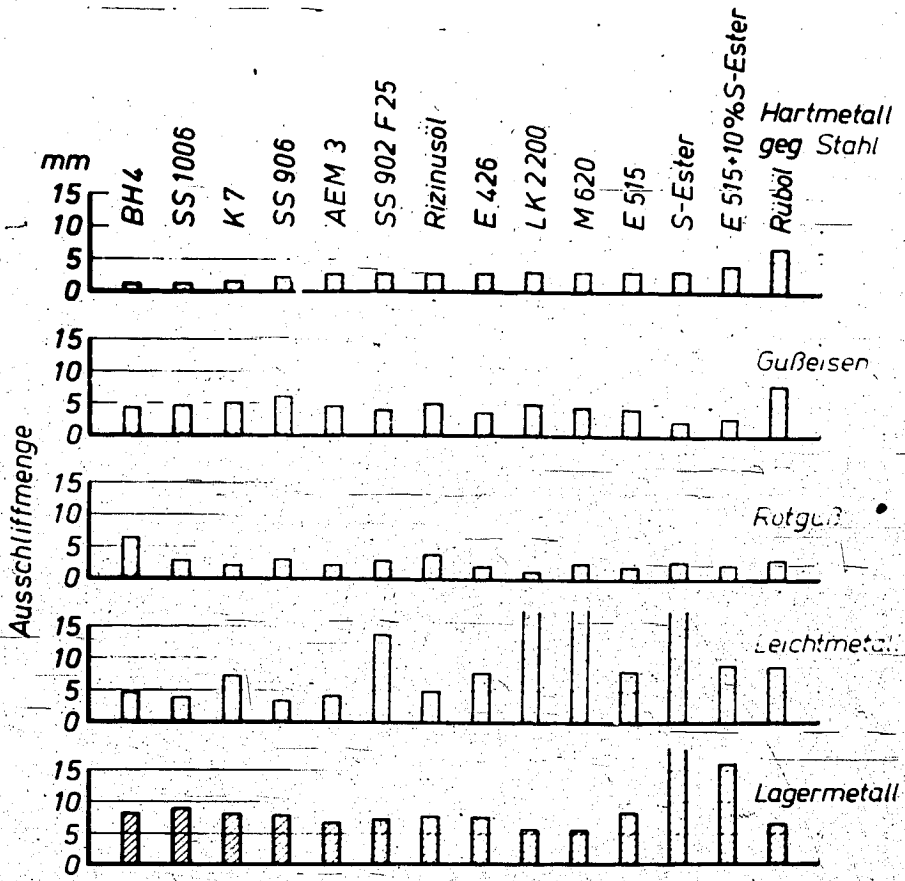
S t o f f	Grenzflächenspannung (dyn/cm) gegen		Haftarbeit H (erg/cm ²) gegen	
	Wasser	Quecksilber	Wasser	Quecksilber
Hexan	51,25	380	40,0	120
Benzol	35,03	366	66,6	143
CCl ₄	43,26	358	56,1	149
C ₆ H ₅ Cl	37,41	350	68,5	163
CS ₂	48,36	341	55,8	170
Mercurtan	26,12	340	68,5	160
Oktanol	8,52	367	90,8	140
Heptylsäure	6,56	335	94,6	173
Ester	etwa 25	etwa 350	etwa 75	etwa 150

57087

Zerreifestigkeit und Haftfestigkeit nach Berechnungen
von K.L. Wolf, Halle

S t o f f	Zerreifestig- keit Z (kg/cm ²)	Haftfestigkeit Z-haft (kg/cm ²)
Cyclohexan	4 900	12 900
Benzol	5 600	14 500
CO ₂	5 600	15 000
Aethanol	4 500	12 000
Propanol	4 700	12 900
Butanol	5 000	12 800
Hexanol	5 300	13 400
Propionsure	5 300	17 400
Buttersure	5 300	17 800
Hexylsure	5 600	17 400
Heptylsure	5 700	17 400
Wasser	14 400	16 700
Quecksilber	96 000	96 000
Messing	5 000	
Eisen	4 000-7 000	

57085.



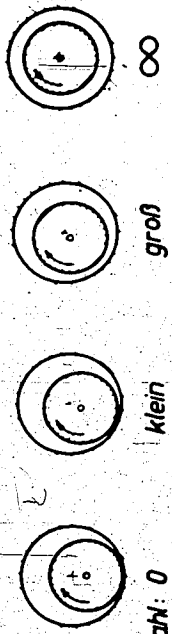
57213

IG
 Ludwigslofena.Rt.
 1943

**Verschleiß verschiedener Metalle
 bei Verwendung verschiedener Öle**

**Techn. Prüfstand
 Oppau
 1412**

Lage der Welle im Lager bei verschiedenen Drehzahlen



Grenz-
schmie-
rung
 $\mu = \frac{R}{N}$

Drehzahl: 0

klein

groß

∞

Vollschmierung $\mu = c \sqrt{\frac{n \cdot v}{p}}$

Teil-
schmie-
rung
A.P.

- Öl A sehr gute Schmierfähigkeit
- - - Öl B mittelmäßige Schmierfähigkeit
- Öl C schlechte Schmierfähigkeit

Verschleiß ohne Verschleiß

Drehzahl → U/min

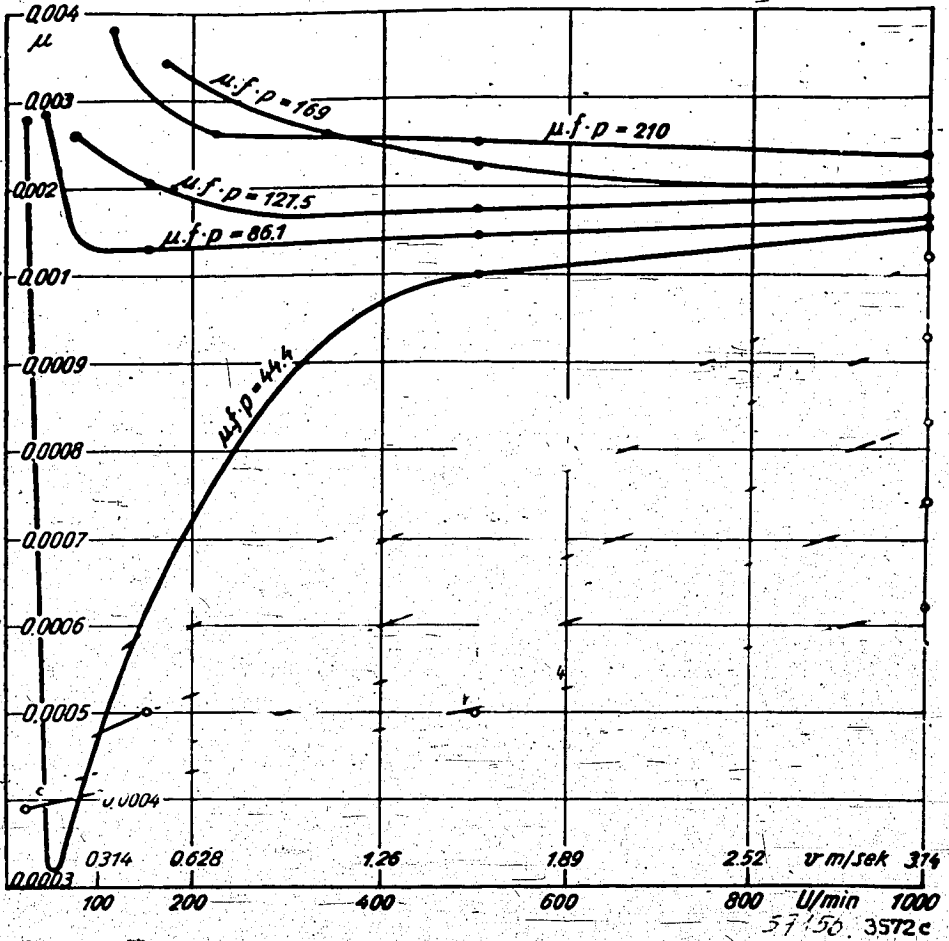
S 1282



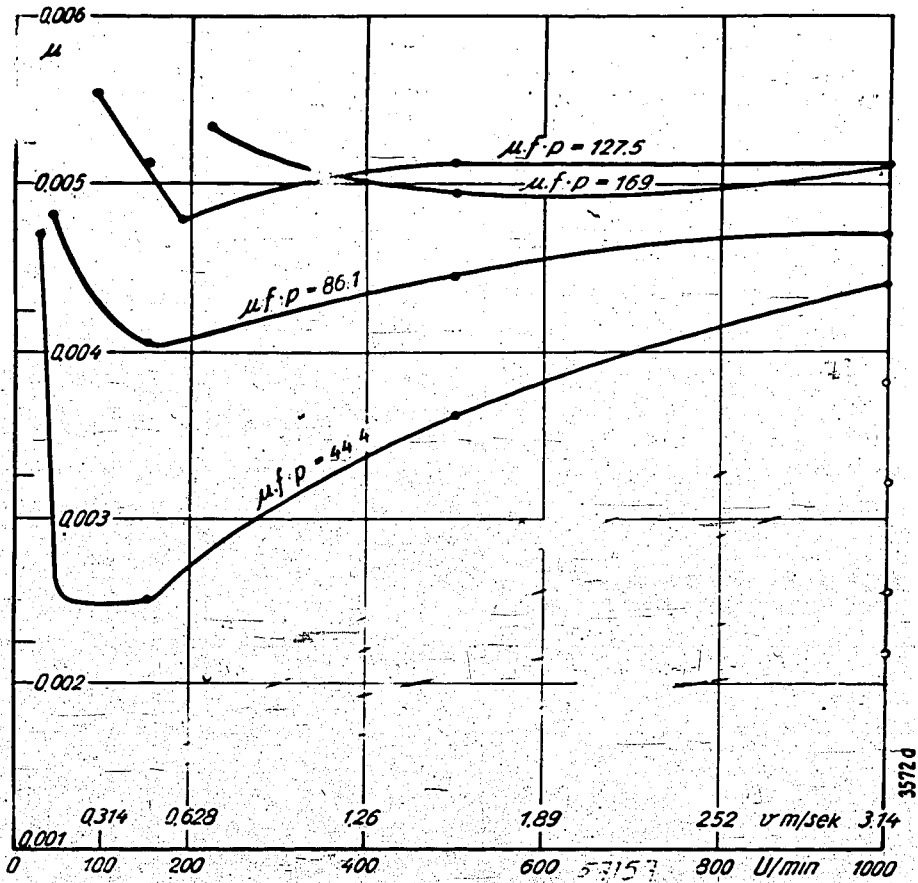
Lehrstuhl für Maschinenelemente
1942

Schmierzustände im Gleitlager
bei 3 Ölen gleicher Viskosität

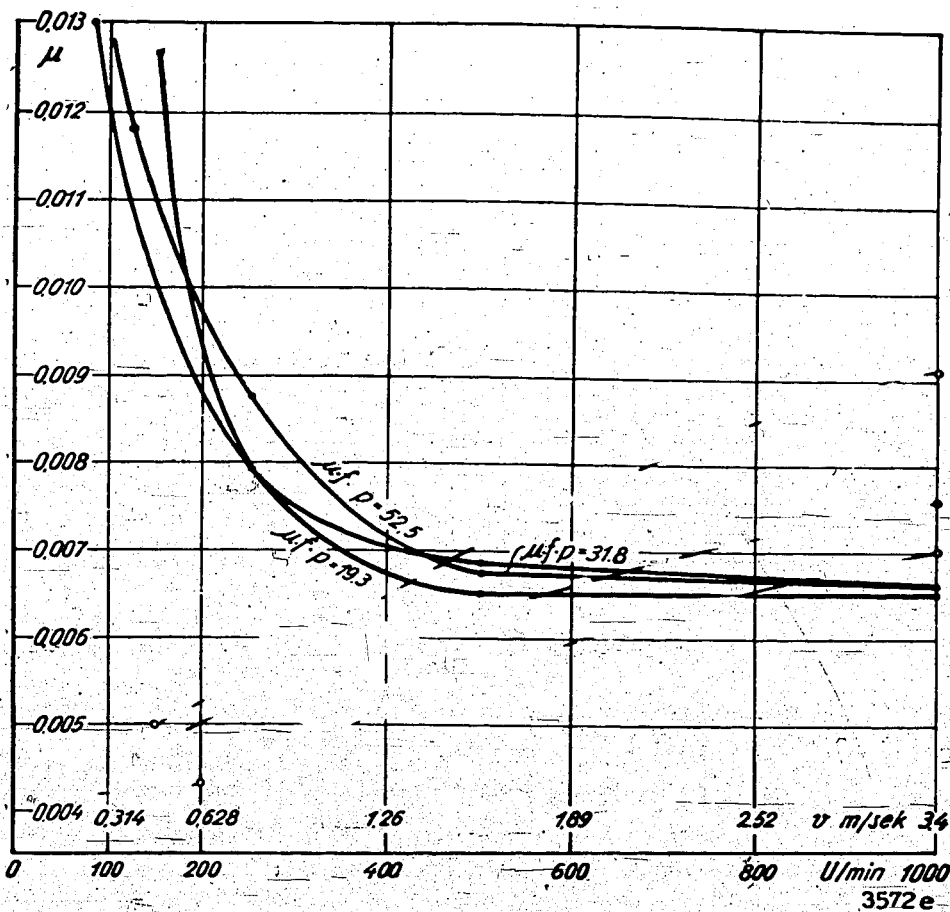
Techn. Prüfstand
Oppau
1180



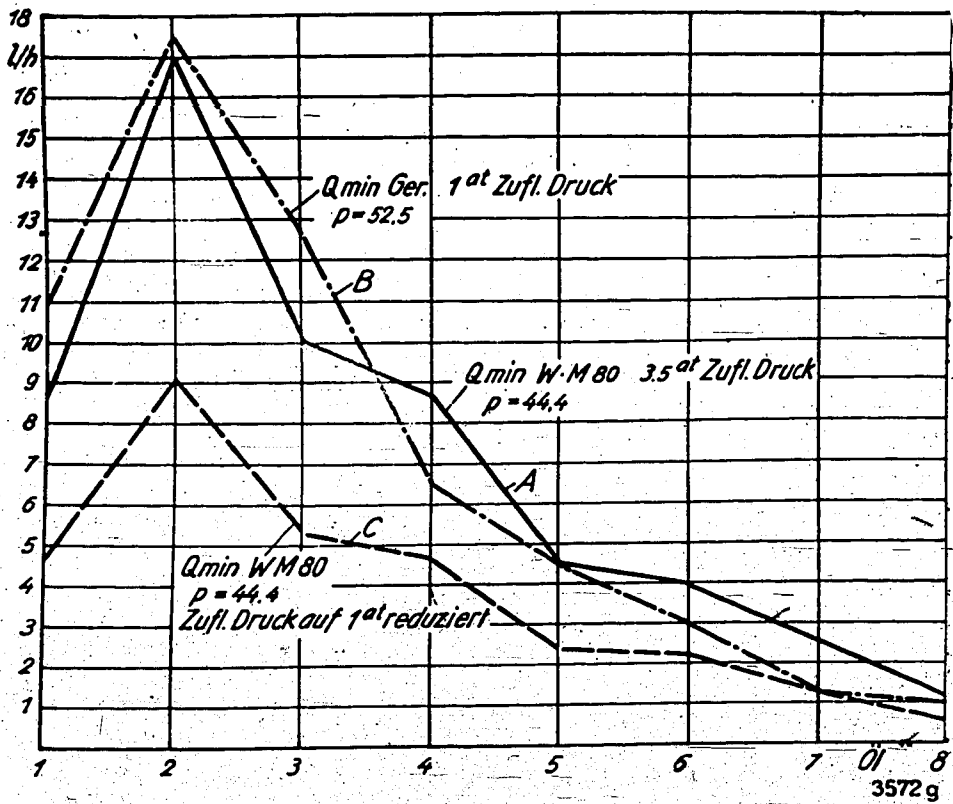
Legierung Weißmetall, 74 Pb, 14,9 Sb, 6,9 Sn, 2,0 Cd, 1,0 Cu,
 1,5 Ni. Spiel 0,25 mm. Öldruck 3,5 at. Öltemperatur 30° C. Öl BC 8
 Reibungswerte μ . — — — — — Temperaturen im Ölfilm



Legierung Weißmetall, 81,63 Pb, 14 Sb, 0 Sn, 3,07 As, 0,98 Cu, 0,01 Ni. Spiel 0,25 mm. Öldruck 3,5 at. Öltemperatur 30° C. Öl BC 8



Buchse aus Kunstharz-Preßstoff Typ T₂, Textilfüllung. Öl BC 8.
 Öldruck 1 at. Öltemperatur 30 °C. Spiel 0,25 mm 57153



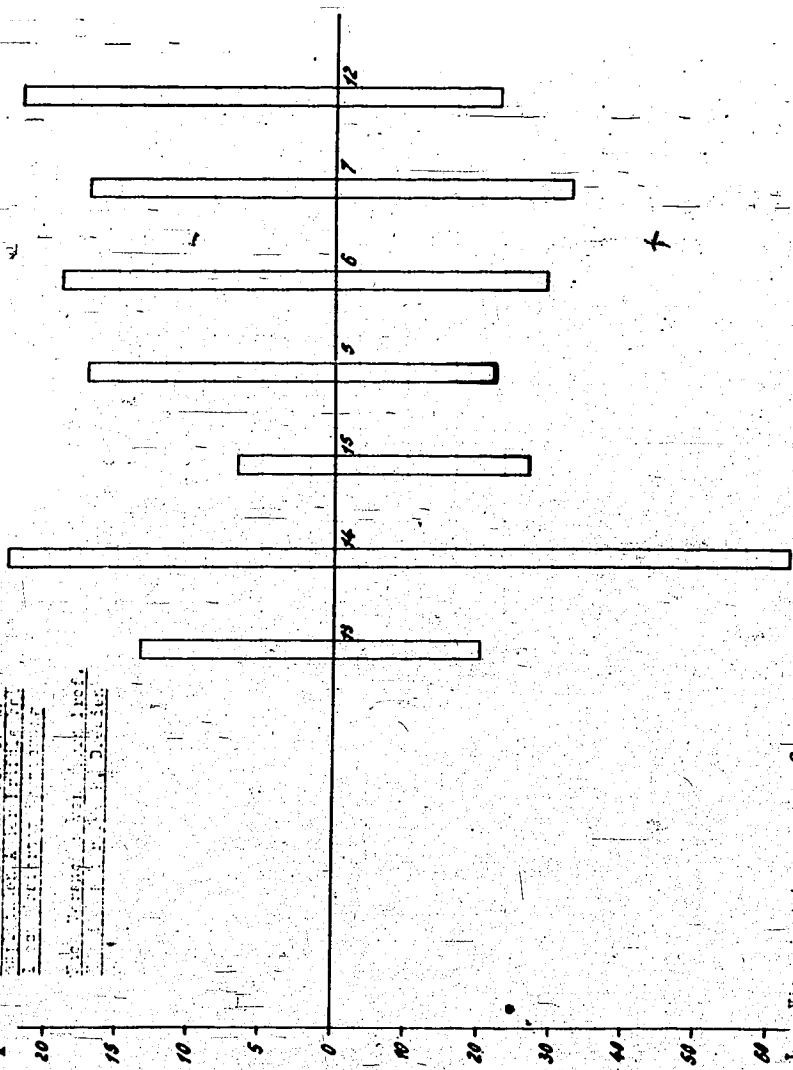
Vergleich der Öldurchlässigkeit zweier Lagerschalen aus WM 80 und Kunstharz-Preßstoff

- Kurve A: WM 80. Öldruck 3.5 at. Öltemperatur 30 ° C. $p = 44.4$
- Kurve B: Kunstharz-Preßstoff. Öldruck 1 at. Öltemperatur 30 ° C. $p = 52.5$
- Kurve C: WM 80. Öldruck red. auf 1 at.

Ölmenge gemessen bei 8 Ölen verschiedener Zähigkeit

57159

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12.
 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100.



1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100.

57097

C. 1 14

O. 1 12

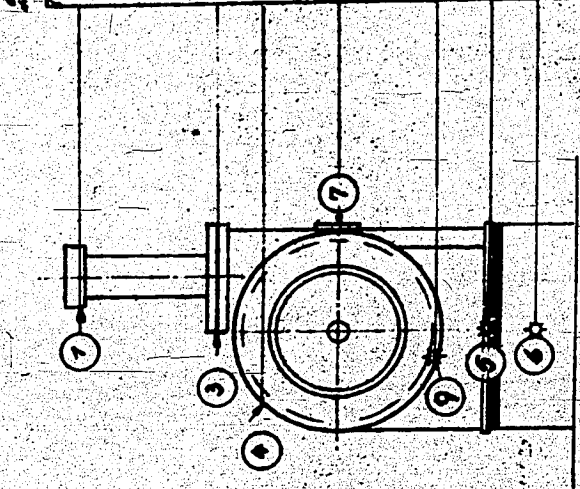
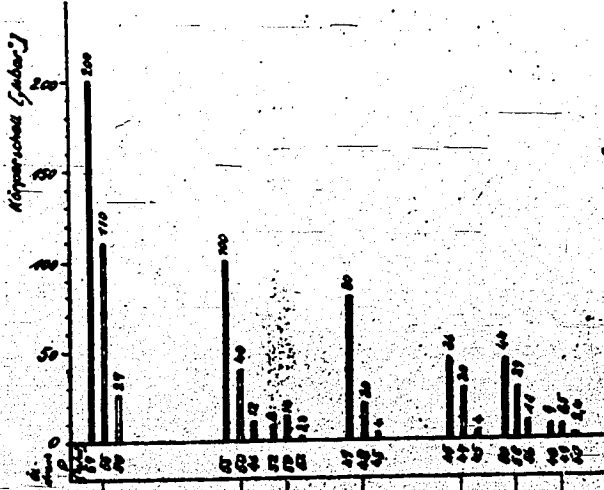
O. 1 6

O. 1 7

O. 1 5

C. 1 15

C. 1 1



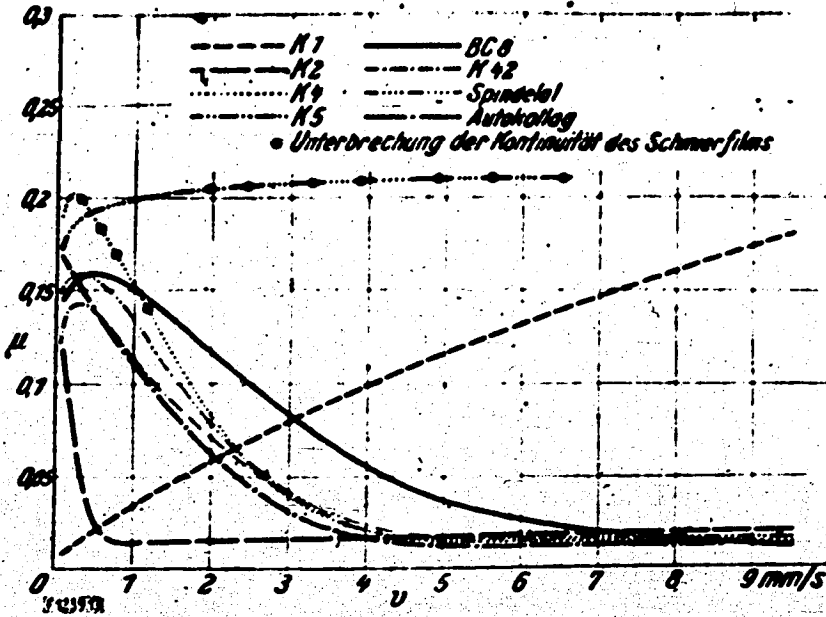
- 1 Normschlüssel der EM.
- 2 Nr. 26 2/10 } der Zimmereisenwerkzeuge
- 3 Nr. 26 2/10 }

57161

Körperschal an verschiedenen Punkten der Sechsrwinde

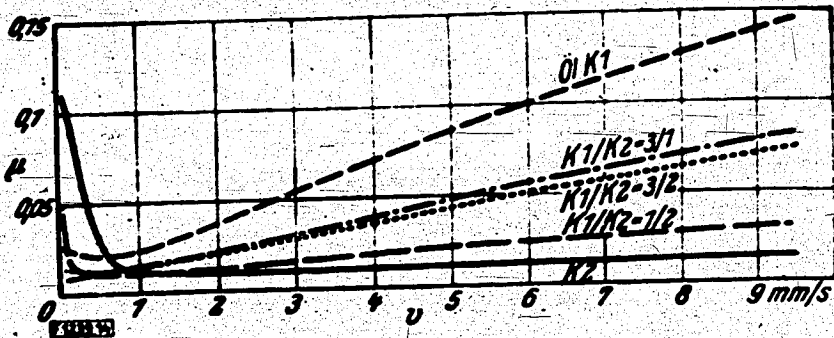
Fried. Krupp
Gesellschaft A.G.
Rtr.

| | |
|-------------------------|-----------|
| Arb.-Nr. 663933 Gr: 116 | |
| Typ: | No BK. 42 |
| No BK. 42 | Bl. 4 |



Einfluß verschieden zäher Schmiermittel auf den Reibungsverlauf.

Lager: Nida-Bronze; Welle: C Stahl, gehärtet, poliert; spez. Lagerbelastung: $p = 8,8 \text{ kg/cm}^2$; Lagerspiel: $s = 0,015 \text{ mm}$.

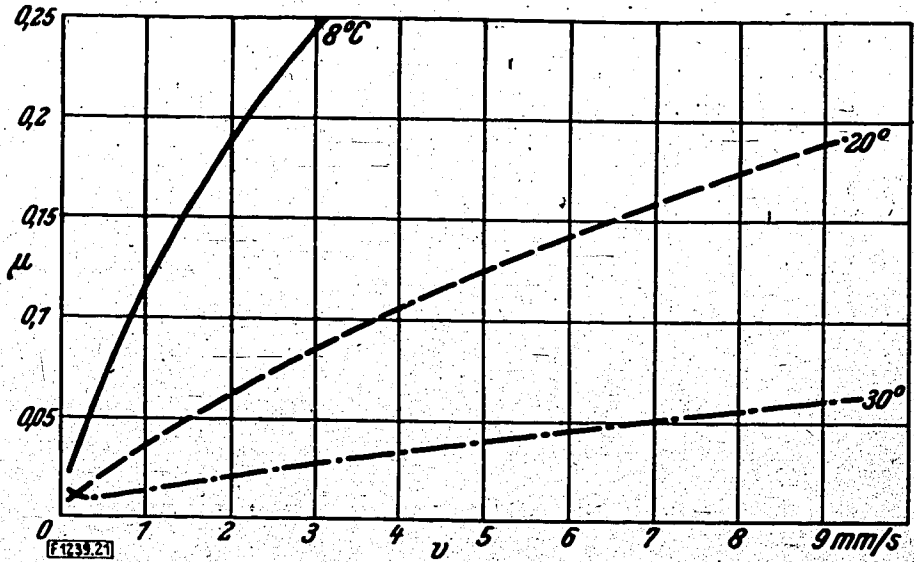


-Reibungsverlauf bei verschiedenen Mischungen der Öle K 1 und K 2.

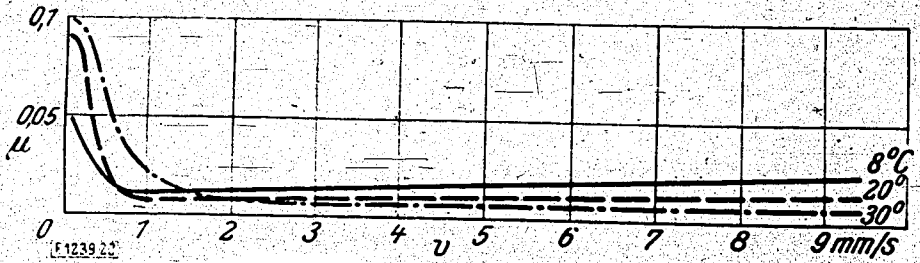
Lager: Thermit; Welle: C-Stahl, gehärtet, poliert; spez. Lagerbelastung: $p = 8,8 \text{ kg/cm}^2$; Lagerspiel: $s = 0,015 \text{ mm}$

57154

R. 14



ÖI K 1.



ÖI K 2.

57155

Kette - Verhalten einiger L. G. - Ü 1 e

| Ü 1 Nr. | Viskosität in cSt | | | Zündplättchen
aufgesetzt bei: | Zündplättchen
eingebaut bei: | Schuss losgerungen
bei: |
|---------|-------------------|-------|-------|----------------------------------|---------------------------------|----------------------------|
| | -62° | -60° | -58° | | | |
| 463 | - | 34650 | 21300 | - 60° | - 59° | - 58° |
| 494 | 16100 | 11880 | 8330 | - 62° | - 61° | - 60° |
| 495 | 11220 | 8870 | 6130 | - 64° | - 63° | 62,5° |

51026

L. G. - U 1 e

| r. | U 1 e r t | Stoßpunkt unter | Viskosität in Ost. bei | | | m | VP | 50 Schuss in Sekunden | Dauerbeschuss | Kaltstart bei | | |
|-----|--|-----------------|------------------------|------|------|------|-------|-----------------------|---------------|---------------|---------------------|--------------|
| | | | -55° | +20° | +38° | | | | | | +99° | |
| 40 | L. G. - U 1 | -55 | - | 35,2 | 16,4 | 3,47 | 3,406 | 1,763 | 2,50 | 2,51 | nach 3000 gut | bis -25° gut |
| 455 | Adipin - S + L. A 140/200 | -78 | 4020 | 13,7 | 7,56 | 2,33 | 3,074 | 1,136 | | | | |
| 463 | S 455 + 2% S als
C ₅ H ₁₁ -O-C ₈ -S-S-C ₈ -O-C ₅ H ₁₁ | -78 | 10720 | 14,1 | 7,82 | 2,28 | 3,215 | 1,282 | 2,55 | 2,50 | nach 3000 gut | -- |
| 463 | S 455 + 3% S | -78 | 11000 | 14,3 | 7,90 | 2,29 | 3,221 | 1,424 | 2,50 | 2,52 | nach 3000 gut | -- |
| 469 | K7 - U 1 + 3% S | -78 | 2765 | 12,0 | 6,96 | 2,17 | 3,129 | 1,145 | 2,50 | 2,50 | nach 2500 gefressen | -- |
| 495 | K7 - U 1 + 5% S | -78 | 3185 | 11,9 | 7,07 | 2,16 | 3,181 | 1,204 | 2,50 | 2,50 | nach 3000 gut | gut |
| 494 | S 455 - U 1 + S 455 111 + 2,5% S | -78 | 5290 | 13,0 | 7,40 | 2,22 | 3,186 | 1,233 | 2,52 | 2,50 | nach 3000 gut | gut |

51045

K. G. - Ö l e

| Nr. | Ö l a r t | Stoßpunkt
unter | Viskosität in cSt. | | | | m | V P | 50 Schme
in Sekunden | | Dauerbeschuss
Schmusszahl | Kaltstar-
bei
- 60° |
|--------|---|--------------------|--------------------|------|------|------|-------|-------|-------------------------|------|------------------------------|---------------------------|
| | | | -55° | +20° | +36° | +99° | | | Anfang | Ende | | |
| 376 | 1,4 Butanol + L S 140-3 | -76 | 2640 | 9,00 | 5,31 | 1,78 | 3,197 | 1,07 | 3,00 | 2,80 | nach 125 gefressen
gut | |
| 380 | Alpin-S + L A 140-3 | -77 | 8160 | 14,5 | 7,87 | 2,34 | 3,137 | 1,211 | 2,8 | - | " 250 " | |
| 390 | Adipin-S + L A 165/250 | -76 | 12220 | 21,1 | 10,5 | 2,82 | 3,136 | 1,339 | 3,0 | 2,80 | " 3000 " | |
| 394 | 1 - Nonylphosphat | -78 | 2963 | 11,8 | 6,60 | 2,20 | 2,968 | 0,975 | 2,65 | 2,77 | bis
gut | |
| 390S | Zetar 290 + 1% S selbst | -76 | 18360 | 19,3 | 9,00 | 2,51 | 3,193 | 1,333 | 2,70 | 3,00 | " 3000 schwacher
Angriff | |
| 290 CS | Zetar 290 + 2% S als Thioeromalden | -76 | 29180 | 17,7 | 9,20 | 2,51 | 3,23 | 1,384 | 3,00 | - | " | |
| 401 | E 376 + 2% S als:
R-COO-S-O-(CH ₂) ₄ -O-C ₆ H ₅ -O-OOR | -76 | 3510 | 9,11 | 5,31 | 1,82 | 3,122 | 0,949 | 3,00 | - | gut | |
| 402 | E 376 + 4% S wie 401 | -76 | 2801 | 9,44 | 5,79 | 1,92 | 3,143 | 1,066 | 2,80 | 3,00 | " | |
| 403 | E 376 + 2% S als:
R-CO-O-CH ₂ -CH ₂ -S-S-CH ₂ -CH ₂ -O-COR | -76 | 6210 | 11,4 | 6,49 | 2,06 | 3,15 | 1,13 | 2,80 | - | " | |
| 404 | E 376 + 2% S als:
R-COO-CH ₂ -S-CS-O-(CH ₂) ₄ -O-CS-S-CH ₂ -R-COO | -76 | 6720 | 10,6 | 6,14 | 1,97 | 3,178 | 1,131 | 2,84 | - | " | |
| 405 | E 376 + 2% S als:
R-O-CS-S-O-(CH ₂) ₄ -O-S-S-O-R | -76 | 7200 | 11,0 | 6,25 | 1,97 | 3,219 | 1,182 | 2,50 | 2,66 | nach 3000 gut | |
| 441 | E 376 + 2% S als:
R-O-CS-S-S-CS-O-R | -78 | 2165 | 10,6 | 6,04 | 1,96 | 3,159 | 1,103 | 2,50 | 2,65 | nach 3000 gut | |
| 442 | E 376 + 2% S als:
R-O-CS-S-S-S-CS-O-R | -76 | 1672 | 10,6 | 6,04 | 2,02 | 3,259 | 1,352 | 2,50 | 2,50 | nach 3000 gut | |

57027

Deutsche Aachsenöle.

| | Winteröl
2/191 III | Winteröl
2/1 III | Winteröl
2/166 III | Winteröl
2/194 III | Winteröl
2/61 III |
|--|-----------------------|---------------------|-----------------------|-----------------------|----------------------|
| Asphalt | 0,08 | 0,7 | 1,0 | 0,02 | 0,2 |
| Harz
CHCl ₃ | 8,7 | 11,8 | 11,3 | 15,5 | 13,3 |
| Carbons
Py | 3,4 | 3,0 | 1,8 | 1,6 | 1,6 |
| H ₂ O ₄ - Lösliches
6 x 2 bis 3 oom | 18,2 | 16,7 | 20,9 | 18,0 | 11,7 |
| Aceton - Unlösli. 20° | 3,3 | 6,9 | 10,4 | 4,6 | 9,8 |
| Paraffin | 2,0 | 2,2 | 2,9 | 4,5 | 3,9 |
| KV - Öle | 64,6 | 58,6 | 51,4 | 57,9 | 58,7 |

50 366

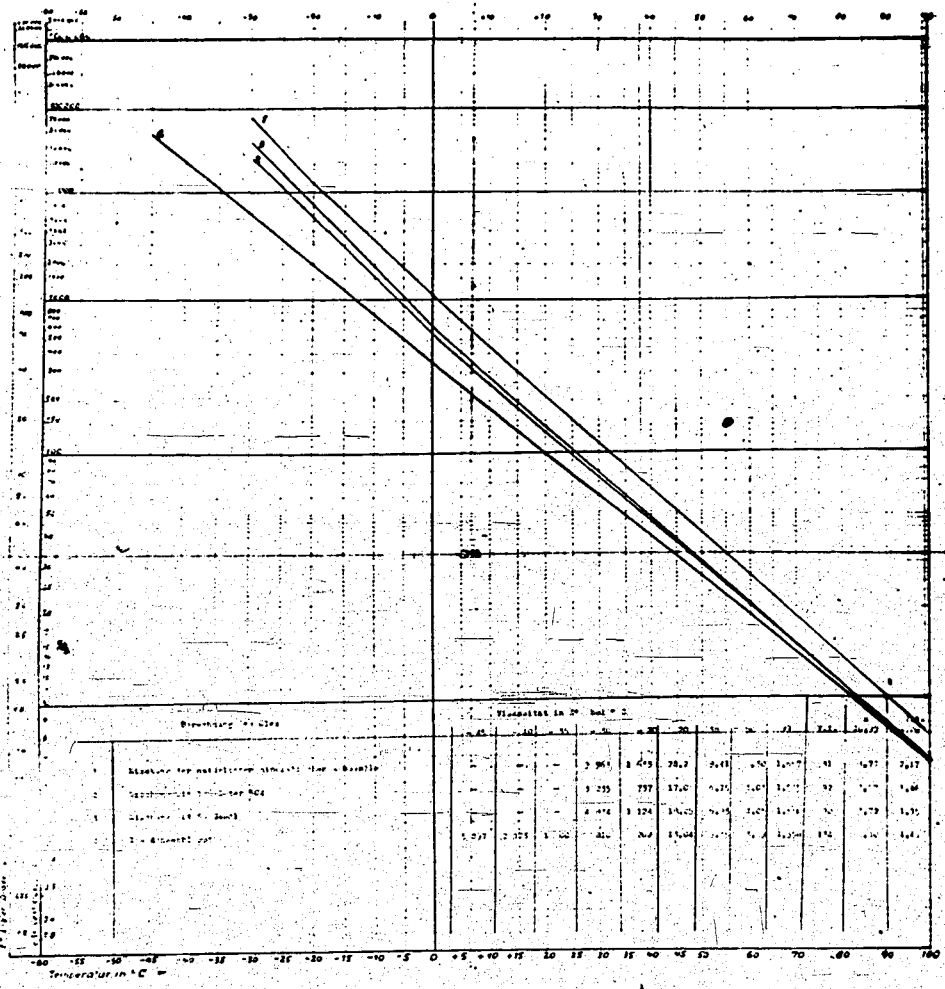
| Clart | Stockpunkt
o. C | Viskosität in 20 bei: | | | | | V. J. |
|---------------------------------|--------------------|-----------------------|-------|-------|-------|-------|-------|
| | | - 30° | - 20° | + 38° | + 50° | + 90° | |
| 1) 2/166 | - 40 | 16380 | 2583 | 10,97 | 6,00 | 1,713 | 75 |
| 2) 2/191 | - 34 | 37100 | 1710 | 8,61 | 4,61 | 1,600 | 73 |
| 3) 2/1 | - 43 | 7076 | 1311 | 8,24 | 4,78 | 1,638 | 98 |
| 4) 2/61 | - 44 | 5359 | 1248 | 8,27 | 4,85 | 1,643 | 98 |
| 5) 2/194 | - 38 | nicht
messbar | 1482 | 8,21 | 4,83 | 1,658 | 104 |
| Mischungen | | | | | | | |
| 6) 2/166 + 2/191 1 : 1 | - 35 | 24630 | 2192 | - | - | - | - |
| 7) 2/1 + 2/61 + 2/194 1 : 1 : 1 | - 35 | 6574 | 1155 | - | - | - | - |
| 8) 2/61 + 2/194 1 : 1 | - 40 | 8300 | 1270 | - | - | - | - |
| 9) 2/1 + 2/194 1 : 1 | - 34 | 7273 | 1225 | - | - | - | - |
| 10) 2/1 + 2/61 1 : 1 | - 42 | 6093 | 1322 | - | - | - | - |
| 11) Mischung 1 - 5 | - 35 | 9593 | 1595 | 9,41 | 5,30 | 1,657 | 81 |
| 12) Ester 436 | - 74 | 52,0 | 20,3 | 1,75 | 1,53 | 1,171 | 169 |
| 13) M 1 - 5 + 12% Ester | - 40 | 3235 | 729 | 6,75 | 4,03 | 1,543 | 95 |
| 14) Mischung 7 + 6% Ester | - 41 | 3390 | 931 | 7,11 | 4,23 | 1,584 | 101 |
| 15) " 7 + 12% " | - 44 | 2285 | 660 | 6,07 | 3,74 | 1,521 | 102 |

50765

Saugvermögen natürlicher Acheenble

| Ö l a r t | bei + 50° | | Gesamt-
menge | bei + 20° | | Gesamt-
menge | bei - 10° | | Gesamt-
menge |
|------------------------------|-----------|----------|------------------|-----------|----------|------------------|-----------|----------|------------------|
| | 1. Woche | 6. Woche | | 1. Woche | 6. Woche | | 1. Woche | 6. Woche | |
| 1 | 379 | 265 | 1912 | 128 | 120 | 760 | 0,1 | 4,3 | 25 |
| 2 | 299 | 101 | 1050 | 20 | 0,6 | 26 | 0 | 0,5 | 0,9 |
| 3 | 389 | 325 | 2123 | 126 | 119 | 756 | 3,8 | 9 | 52 |
| 4 | 355 | 181 | 1517 | 90 | 81 | 529 | 0 | 1,3 | 4,5 |
| 5 | 409 | 349 | 2232 | 122 | 117 | 741 | 0,4 | 4,4 | 23 |
| Gemisch 1 - 5 | 378 | 243 | 1807 | 81 | 22 | 245 | 0,1 | 2 | 12 |
| Gemisch 1 - 5
+ 12% Ester | 511 | 359 | 2525 | 121 | 52 | 461 | 0,8 | 3,4 | 22 |
| Gemisch 1 - 5
+ 10% Gasöl | 432 | 240 | 1980 | 152 | 141 | 901 | 11 | 18 | 114 |

57464

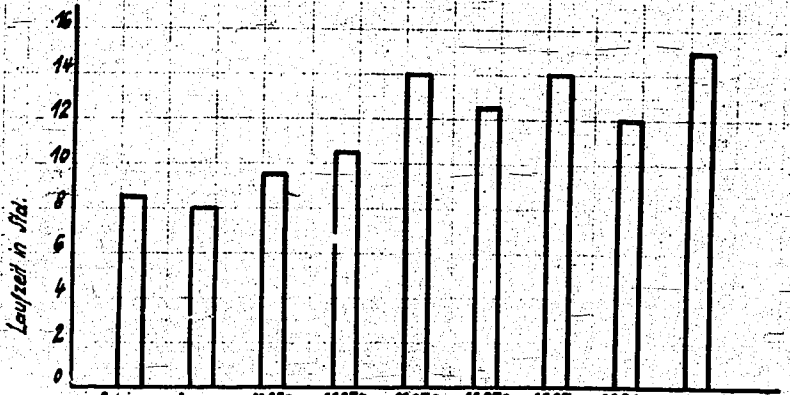
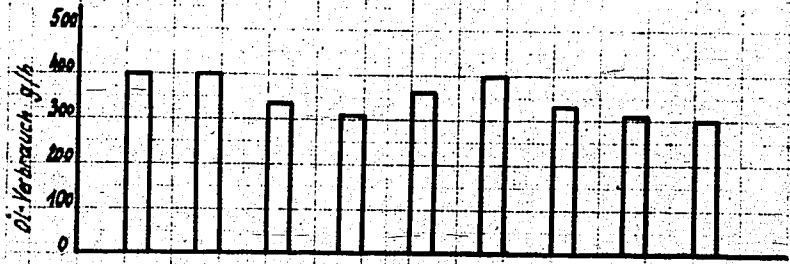
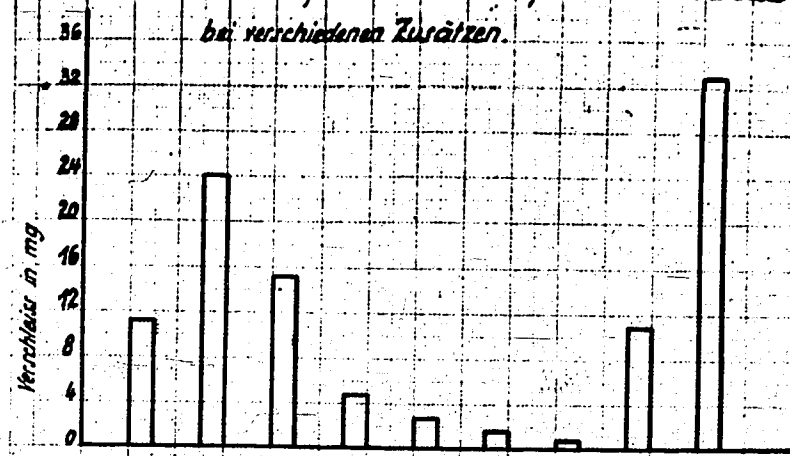


| Berechnung des Q ₂ | | Temperatur in °C bei $\phi = 0.5$ | | | | | | | | | |
|-------------------------------|---|-----------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| | | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 |
| 1 | Rechnung der Luftmenge $Q_{2,1}$ für $\phi = 0.5$ | — | — | 2 365 | 2 453 | 2 543 | 2 632 | 2 722 | 2 812 | 2 902 | 2 992 |
| 2 | Rechnung der Luftmenge $Q_{2,2}$ | — | — | 2 255 | 2 337 | 2 420 | 2 503 | 2 587 | 2 671 | 2 755 | 2 839 |
| 3 | Rechnung der Luftmenge $Q_{2,3}$ | — | — | 2 474 | 2 524 | 2 574 | 2 624 | 2 674 | 2 724 | 2 774 | 2 824 |
| 4 | Rechnung des $Q_{2,4}$ | 1 577 | 1 577 | 1 577 | 1 577 | 1 577 | 1 577 | 1 577 | 1 577 | 1 577 | 1 577 |

57100 / 1.5.1956

*Verbleiss, Verbrauch und Laufzeit
bei verschiedenen Zusätzen.*

Blatt 6



Rohring D Jenove 100 SS970 a SS970 af/2 SS970 af SS970 F SS970 a2F SS90+ a SS90+ GD 470

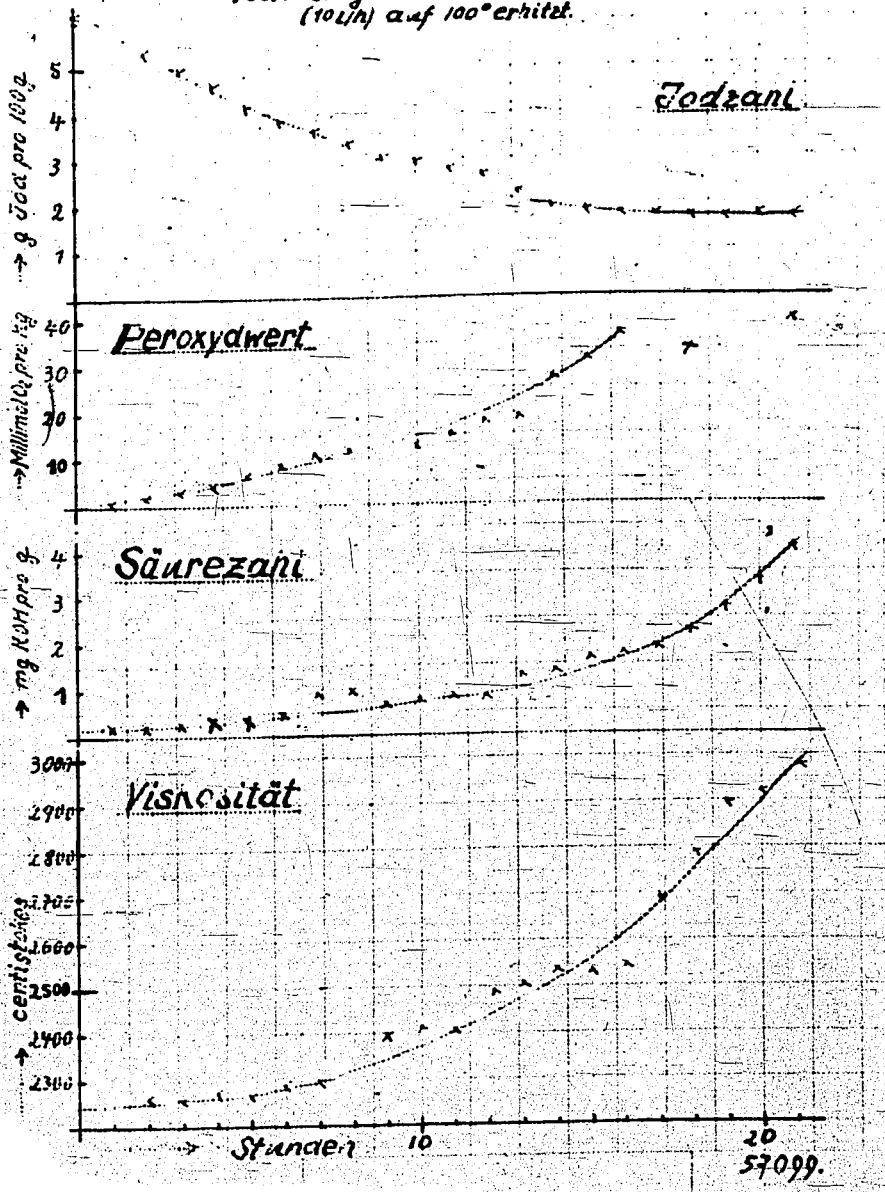
46849

| Nr. Nr. | SS 970 = SS 906 + Mischzahl 1:1
und Zusatz eines Esters γ | Laufzeit
in
Stunden | Verbesserung der
Laufzeit
gegenü. Notring | Verbrauch
g/Std. | Viskosität
η_{sp}
bei 99° | V.I. |
|---------|---|---------------------------|---|---------------------|--------------------------------------|------|
| 464 | R o t r i n g D | 8,5 | | 400 | 2,95 | 93 |
| 470 | SS 970 a | 11 | 29 % | 360 | 3,50 | 115 |
| 474 | SS 970 a + 5 % γ | 10,5 | 23 % | 310 | 3,23 | 109 |
| 472 | SS 970 a + 10 % γ | 14 | 65 % | 335 | 3,05 | 109 |
| 580 | SS 970 a + 20 % γ | 14 | 65 % | 330 | 2,50 | 103 |
| 475 | SS 970 a + 10 % γ | 12,5 | 47 % | 400 | 3,09 | 110 |
| 470 | SS 904 a | 12 | 41 % | 310 | 3,08 | 116 |
| 518 | SS 904 a + 10 % γ | 19,5 | 129 % | 400 | 2,62 | 114 |
| 524 | SS 904 a + 20 % γ | 23,0 | 170 % | 405 | 2,34 | 112 |

4575

Oxydative Veränderungen von SS-Öl 906

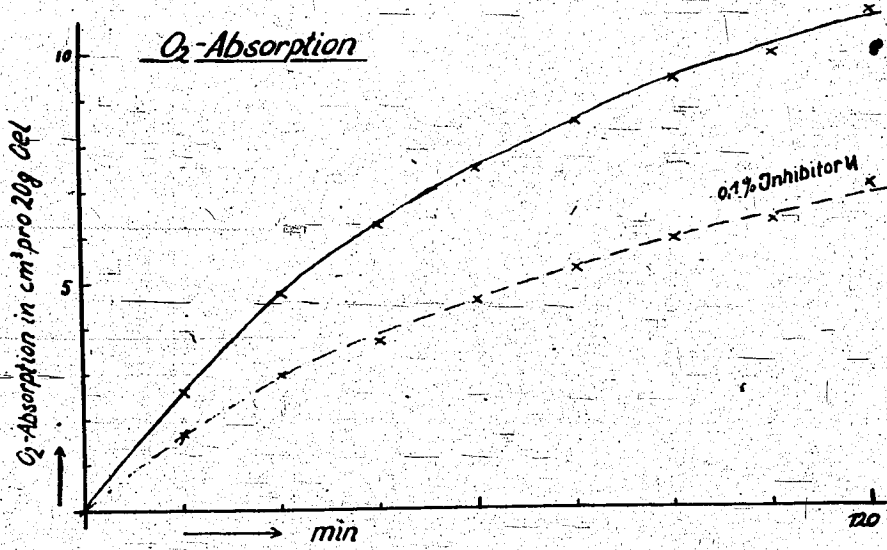
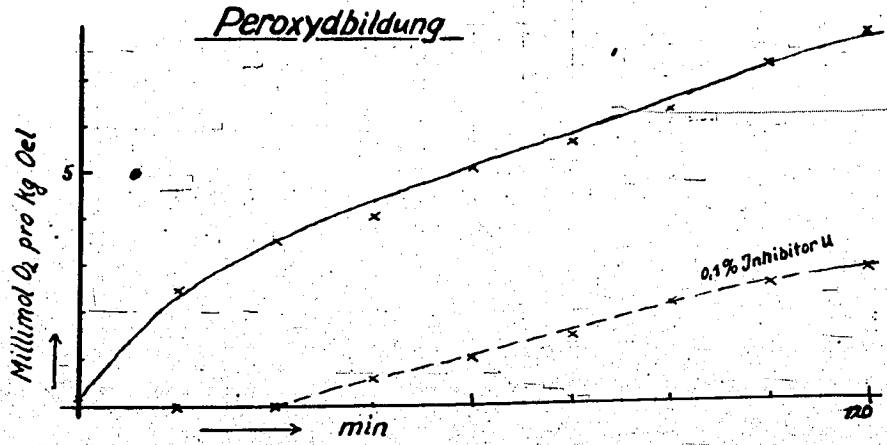
Test: 200g Öl werden unter Durchleiten von O_2
(10 l/h) auf 100° erhitzt.



57099.

Oxydative Veränderungen von SS-Oel 906

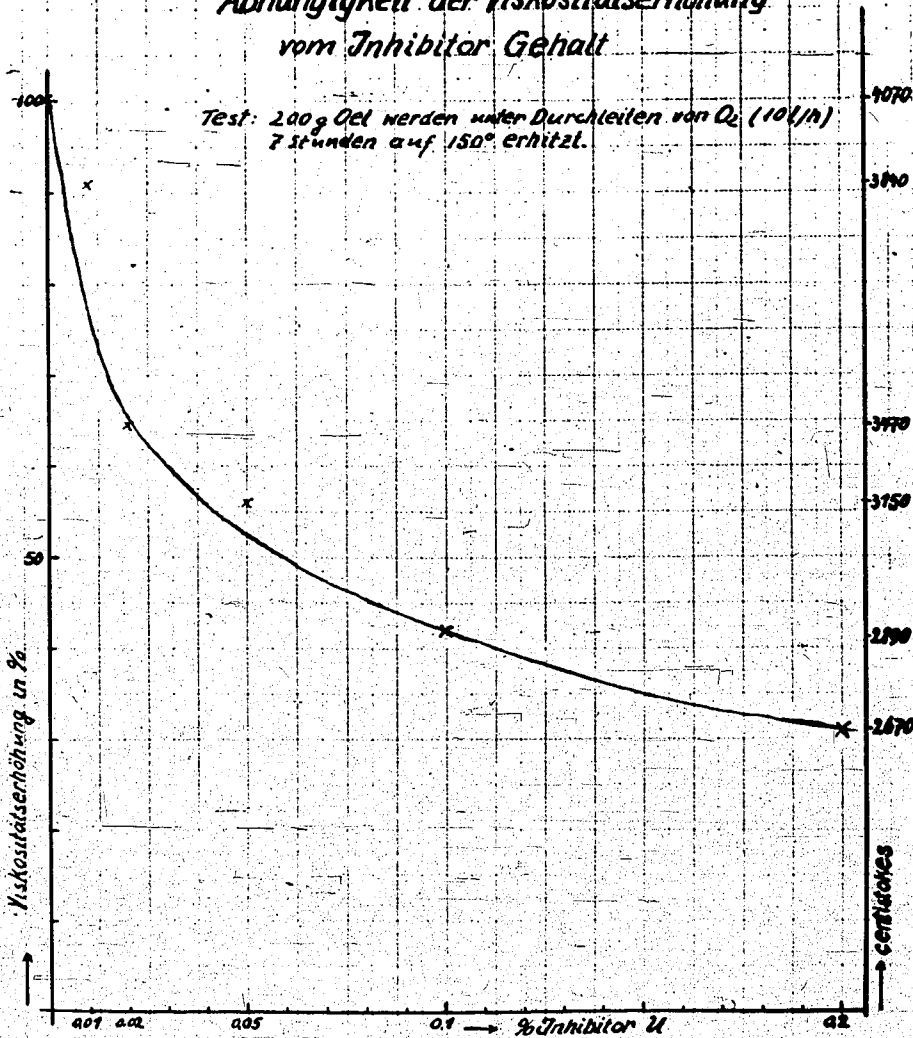
Test: 20g Oel werden in O_2 -Atmosphäre unter intensiver Rührung mit UV-Licht bestrahlt. Temp 40°



Oxydative Veränderungen von SS-Öl 906

Abhängigkeit der Viskositäts-erhöhung vom Inhibitor Gehalt

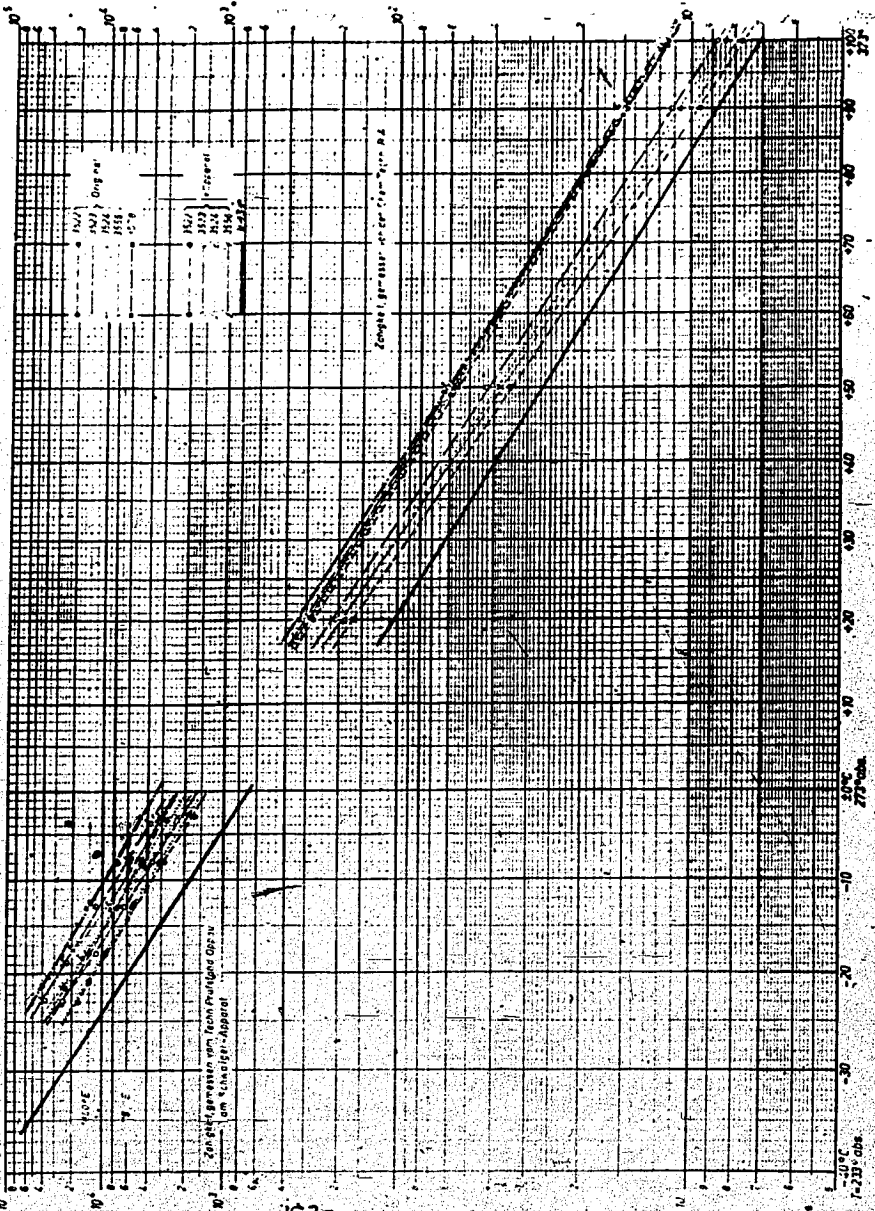
Test: 200 g Öl werden unter Durchleiten von O_2 (10 l/h) 7 Stunden auf 150° erhitzt.



57091

Techn. Prüfstand Op 471

Blatt 1

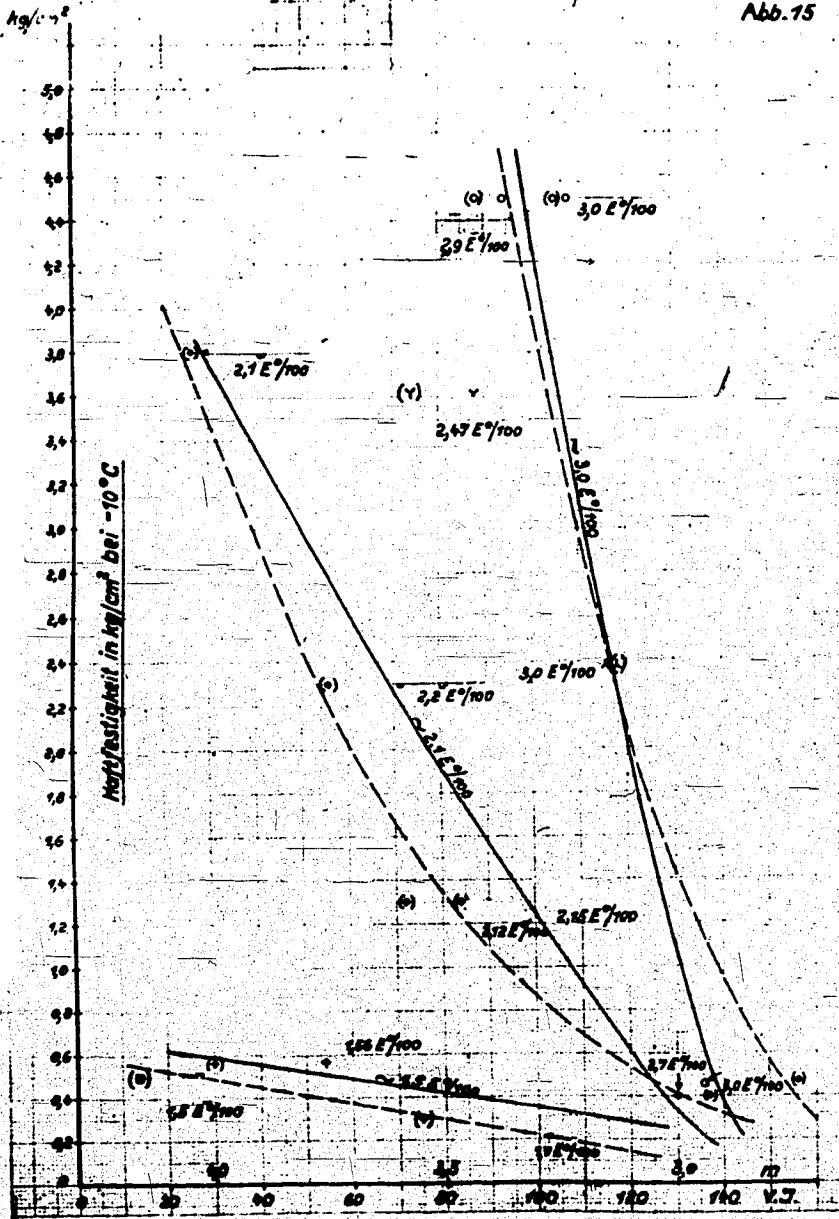


J.G. Rechenmaschinenfabrik
Ludwigshafen a.Rh.

5. Heftchen von Dr. Henr. v. L. R. 1914

57162. T.P.S. 232

Abb. 15



42 b74

Prüfung des Kälteverhaltens
im J.G. Kälteschrank

- ——— 3078
- ——— 3194
- ——— 3094
- ▲ ——— 3089
- ——— 3522
- ——— 3523 } Original
- △ ——— 3524
- x ——— 3525
- ——— K 10 AC
- ——— 3522 } z. Oppau
- ——— 3523
- △ ——— 3524
- x ——— 3525
- + K 13

Kälteleistung
W/m²

40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
9.8
9.6
9.4
9.2

-40

-35

-30

-25

-20

-15

-10

Temp. °C

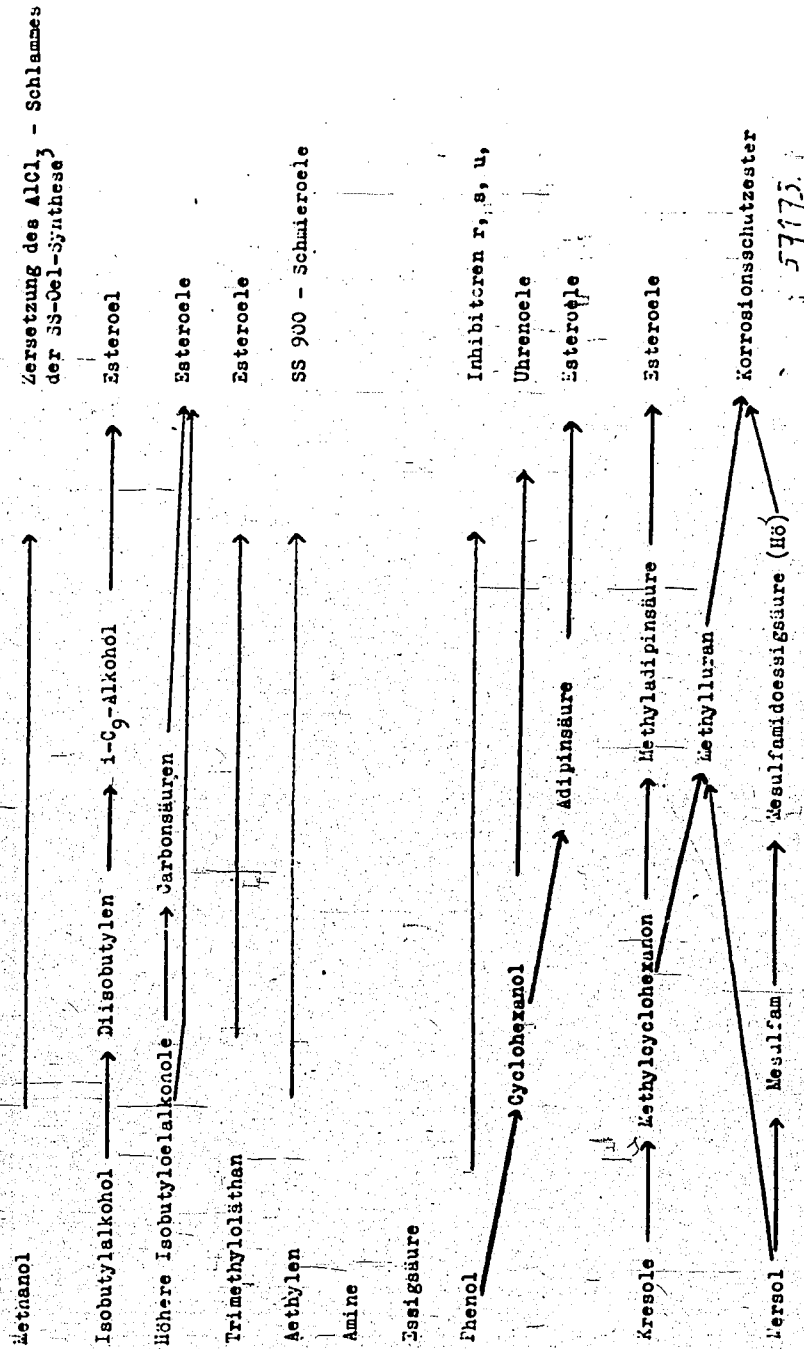
57160.

| Nr. | Ö l a r t | Laufzeit - Verbesserung gegenüber Stanayo. |
|-----|--|--|
| 1 | Schmieröledestillat aus Nienhagener Öl mit $AlCl_3$ raffiniert + SS 1100 1 : 1. | 23 % |
| 2 | Mischpolymerisat aus dem obigen Nienhagener Öl und Paraffinackprodukt 1 : 1 | 48 % |
| 3 | Nienhagener - Schmieröledestillat mit Propan behandelt dann mit $AlCl_3$ raffiniert und gemischt mit SS 1100 1 : 1 | 25 % |
| 4 | Nienhagener Schmieröledestillat mit Propan behandelt mischpolymerisiert mit Paraffinackprodukt 1 : 1 | 100 % |

45174

Produkt

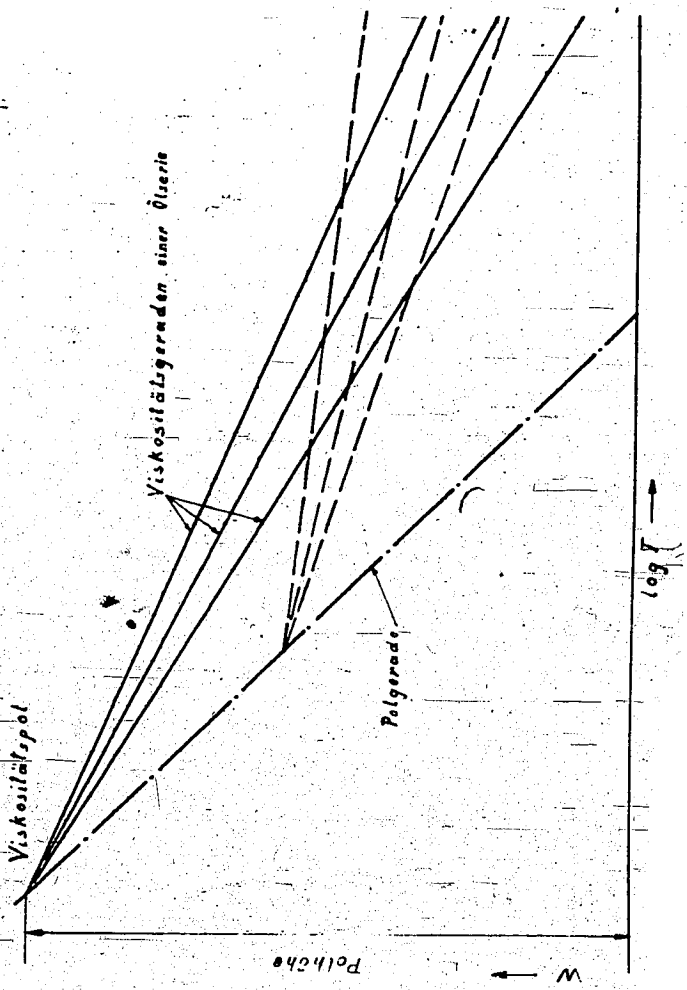
Verwendung auf dem
Schmierstoff-Gebiet



Zersetzung des $AlCl_3$ - Schlammes
der SS-Oel-Synthese

57175

Viskosität-Temperatur-Geraden von zwei Ölserien verschiedener Herkunft.



45103

Ester aus drei- und vierwertigen
Alkoholen

| | spez. Gew.
20° C | Viskosität in cSt
bei ° C | | | | Stock-
punkt
° C |
|--|---------------------|------------------------------|-------|-------|-------|------------------------|
| | | 20 | 38 | 50 | 99 | |
| $\begin{array}{c} \text{CH}_2 \text{ OH} \\ \\ \text{CH}_2 - \text{C} \\ \\ \text{CH}_2 \text{ OH} \\ \\ \text{CH}_2 \text{ OH} \end{array}$ | | | | | | |
| + n-Octylsäure | 0,944 | 36,20 | 17,75 | 11,96 | 3,86 | 3,58 - 8 |
| $\begin{array}{c} \text{CH}_2 \text{ OH} \\ \\ \text{CH}_2 - \text{C} \\ \\ \text{CH}_2 \text{ OH} \\ \\ \text{CH}_2 \text{ OH} \end{array}$ | 0,948 | 37,00 | 18,00 | 12,20 | 3,96 | 3,57 - 69 |
| $\begin{array}{c} \text{CH}_2 \text{ OH} \\ \\ \text{HC} - \text{CH}_2 - \text{C} - \text{CH}_2 \text{ OH} \\ \\ \text{OH} \end{array}$ | 0,940 | 25,34 | 12,97 | 8,98 | 3,20 | 3,57 - 24 |
| $\begin{array}{c} \text{CH}_2 \text{ OH} \\ \\ \text{HC} - \text{CH}_2 - \text{C} \\ \\ \text{CH}_2 \text{ OH} \\ \\ \text{CH}_2 \text{ OH} \end{array}$ | 0,959 | 50,79 | 23,80 | 15,69 | 4,73 | 3,50 + 7 |
| Trimethyloäthan | 0,948 | 49,30 | 20,90 | 13,5 | 3,84 | 3,88 - 63 |
| Trimethylolpropan | 0,948 | 64,82 | 26,28 | 16,09 | 4,17 | 4,02 - 58 |
| Glycerin | 0,952 | 40,27 | 17,39 | 11,20 | 3,21 | 4,11 - 66 |
| Pentaerythrit | 0,966 | 143,7 | 52,01 | 29,94 | 6,37 | 3,91 - 45 |
| $\begin{array}{c} \text{CH}_2 \text{ OH} \\ \\ \text{HC} - \text{CH}_2 - \text{C} \\ \\ \text{CH}_2 \text{ OH} \\ \\ \text{CH}_2 \text{ OH} \end{array}$ | 0,949 | 123,0 | 42,50 | 24,75 | 5,57 | 3,96 - 48 |
| + Leuna - Carbon- säuregemisch 200/250 | 0,958 | 144,7 | 50,20 | 28,60 | 6,30 | 3,97 - 49 |
| $\begin{array}{c} \text{CH}_2 \text{ OH} \\ \\ \text{HC} - \text{CH}_2 - \text{C} \\ \\ \text{CH}_2 \text{ OH} \\ \\ \text{CH}_2 \text{ OH} \end{array}$ | 0,954 | 94,4 | 34,0 | 20,7 | 4,93 | 3,96 - 60 |
| Pentaerythrit | 0,961 | 453,0 | 117,2 | 63,5 | 10,46 | 3,88 - 31 |

371199

Ester aus drei- und vierwertigen Alkoholen
Unvollständige Veresterung

| | spez. Gew. | | | | Viskosität in cSt bei 0 C | | | | Stockpunkt
° C |
|----------------------------------|------------|--------|-------|-------|---------------------------|------|------|----|-------------------|
| | 20° C | 36 | 50 | 99 | 20 | 36 | 50 | 99 | |
| Trimethyläthan | 0,917 | 97,90 | 42,13 | 26,60 | 7,11 | 3,34 | - 28 | | |
| + 3 Mol 1-C ₁₃ -Säure | | | | | | | | | |
| Trimethyläthan | 0,925 | 124,5 | 49,50 | 27,87 | 7,27 | 3,51 | - 27 | | |
| + 2 Mol " " | | | | | | | | | |
| Trimethyläthan | 0,949 | 123 | 42,50 | 24,81 | 5,57 | 3,06 | - 46 | | |
| + 3 Mol - Leucarbonensäure | | | | | | | | | |
| " " | 0,962 | 193 | 59,50 | 32,40 | 6,57 | 4,01 | - 44 | | |
| + 2 " " | | | | | | | | | |
| " " | 0,982 | 427 | 105 | 51,5 | 7,80 | 4,34 | - 33 | | |
| + 1 " " | | | | | | | | | |
| Penterythrit | 0,929 | 179,50 | 71,10 | 42,80 | 10,00 | 5,27 | - 28 | | |
| + 4 Mol 1-C ₁₃ -Säure | | | | | | | | | |
| " " | 0,934 | 213,2 | 81,20 | 46,50 | 10,40 | 5,33 | - 27 | | |
| + 3 " " " | | | | | | | | | |
| " " | 0,951 | 339,0 | 114,9 | 64,50 | 11,70 | 5,50 | - 26 | | |
| + 2 " " " | | | | | | | | | |

57082

Ester von Dicarbonsäuren mit verzweigter und
mit cyclischen Alkoholen im Vergleich mit
geradkettigen Alkoholen

| | spez. Gew.
20° C | Viskosität in est.
z bei ° C | | | Stoßpunkt
° C |
|--------------------|---------------------|---------------------------------|-------|-------|------------------|
| | | 20 | 38 | 50 | |
| Mirrisäure | 0,919 | 14,2 | 8,75 | 6,28 | + 10 |
| " | 0,925 | 13,2 | 7,83 | 5,85 | ← - 7 |
| " | -- | -- | -- | 12,90 | + 4 |
| " | 1,002 | 63,70 | 27,70 | 17,60 | - 50 |
| " | 0,946 | 8,76 | 5,35 | 4,06 | ← - 72 |
| 3-äthyladipinsäure | 0,920 | 16,00 | 9,22 | 6,67 | - 36 |
| " | 0,910 | 18,00 | 9,43 | 6,88 | ← - 72 |
| " | 1,025 | 71,0 | 27,27 | 16,40 | - 50 |
| " | 0,993 | 66,9 | 25,73 | 15,60 | - 46 |
| " | 0,943 | 11,67 | 6,49 | 4,77 | ← - 72 |
| | | | | | 57098 |

Äster von Bicarbonäuren

| | spez. Gew. | Viskosität in est bei ° C | | | | m | Stechpunkt
° C |
|---------------------|------------|---------------------------|-------|-------|------|--------|-------------------|
| | | 20° C | 38 | 50 | 99 | | |
| Adipinsäure | 0,919 | 14,2 | 8,75 | 6,28 | 2,85 | 3,09 | + 10 |
| " " | — | — | — | 12,40 | 4,53 | (3,05) | + 36 |
| α-Methyladipinsäure | 0,927 | 16,80 | 9,33 | 6,66 | 2,66 | 3,48 | - 32 |
| α - " " | 0,913 | 36,13 | 17,30 | 12,10 | 4,28 | 3,23 | + 16 |
| β-Methyladipinsäure | 0,920 | 16,00 | 9,22 | 6,67 | 2,90 | 3,16 | - 38 |
| β - " " | 0,898 | 35,90 | 18,60 | 13,20 | 4,71 | 2,96 | + 10 |
| Adipinsäure | 0,930 | 32,73 | 16,40 | 10,85 | 3,65 | 3,60 | - 69 |
| α-Methyladipinsäure | 0,933 | 49,20 | 20,90 | 13,40 | 4,07 | 3,71 | - 60 |
| β-Methyladipinsäure | 0,913 | 49,60 | 21,20 | 13,60 | 4,16 | 3,67 | - 59 |
| Dimethyladipinsäure | 0,932 | 58,70 | 24,20 | 15,50 | 4,29 | 3,85 | - 57 |
| Sebacinsäure | 0,916 | 44,10 | 20,70 | 13,90 | 4,45 | 3,48 | - 70 |
| Adipinsäure | 0,918 | 24,00 | 12,70 | 8,70 | 3,21 | 3,43 | ← - 72 |
| β-Methyladipinsäure | 0,916 | 28,20 | 14,60 | 10,00 | 3,32 | 3,49 | - 70 |
| Dimethyladipinsäure | 0,916 | 30,73 | 15,00 | 10,41 | 3,53 | 3,59 | - 68 |
| Sebacinsäure | 0,911 | 38,33 | 19,50 | 13,40 | 4,71 | 3,20 | - 60 |
| | | | | | | 57002 | |

Fester aus mehrwertigen Alkoholen und dem Halboester (HE)
der Abspinnmaße: HCOO- (CH₂)₄-COOH

H = Leuanalkohol 140/180

| | 20°C | Viskosität in cSt
bei 0 °C | | | m | Stock-
punkt
°C |
|--|----------------|-------------------------------|----------------|----------------|---------------|-----------------------|
| | | 20 | 38 | 50 | | |
| Aethylglykolykol
+ HE
+ n-C ₆ -Säure | 0,982
0,934 | 73,57
5,00 | 20,10
4,38 | 13,30
4,03 | 4,30
1,76 | 20,99
3,47 |
| 1,4-Butylenglykolykol
+ HE
+ n-C ₆ -Säure | 0,993
0,919 | 57,70
11,77 | 20,80
6,85 | 17,20
5,17 | 5,38
2,30 | 3,35
3,30 |
| 1,6-Hexylenglykolykol
+ HE
+ n-C ₆ -Säure | 0,983
0,820 | 64,30
17,40 | 29,53
8,40 | 19,80
6,26 | 6,14
2,62 | 3,10
3,33 |
| 1,4-Ethyl-hexylenglykolykol
+ HE
+ n-C ₆ -Säure | 0,995
0,916 | 87,30
15,40 | 40,20
8,18 | 25,30
6,53 | 7,23
2,71 | 3,33
3,31 |
| Dimethylpropan
+ HE
+ n-C ₆ -Säure | 0,982
0,820 | 64,00
14,50 | 27,90
8,10 | 17,80
5,87 | 5,30
2,36 | 3,46
3,62 |
| Trimethylathan
+ HE
+ n-C ₆ -Säure | 1,011
0,944 | 826
36,20 | 81,25
17,75 | 47,87
11,06 | 16,74
3,66 | 3,30
3,38 |
| Teräcylthrit
+ HE
+ n-C ₆ -Säure | 1,021
0,959 | 482
50,79 | 177,7
23,60 | 101,1
25,69 | 10,50
4,73 | 3,34
3,50 |

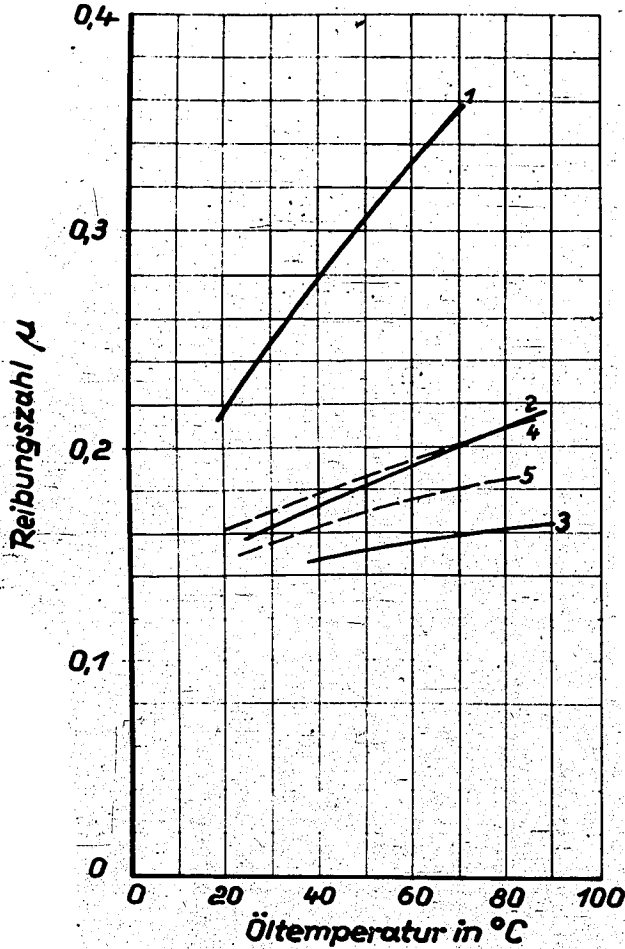
570/86

| Molekülvergrößerung durch Aethoxylierung des
angewandten Alkohols i C ₉ -Oxoalkohol aus
Diisobutyleh | | spek.
Gew. | Viskosität in cSt
bei ° C | | | | Stock-
punkt
° C |
|---|---|---------------|------------------------------|-------|-------|------|------------------------|
| | | | 20 | 38 | 50 | 99 | |
| i C ₉ -Alkohol | + C Mol C ₂ H ₅ C | 0,918 | 24,00 | 12,70 | 8,70 | 3,43 | < - 72 |
| " | + 1 " " | 0,948 | 37,60 | 18,30 | 12,00 | 3,38 | - 65 |
| " | + 2 " " | 0,976 | 50,00 | 27,40 | 18,30 | 3,26 | - 58 |
| " | + 4 " " | 1,002 | 82,80 | 40,00 | 27,60 | 3,13 | - 52 |
| " | + 6 " " | 1,021 | 124,60 | 54,10 | 34,80 | 2,97 | - 38 |
| i C ₉ -Alkohol | + 0 Mol C ₂ H ₅ C + Vethyladipinsäure | 0,916 | 28,20 | 14,60 | 10,00 | 3,52 | - 70 |
| " | + 1 " " | 0,950 | 46,00 | 21,90 | 14,70 | 3,30 | - 60 |
| " | + 2 " " | 0,974 | 67,10 | 39,07 | 19,50 | 3,24 | - 45 |
| " | + 4 " " | 0,998 | 98,00 | 42,30 | 27,10 | 3,00 | - 50 |
| " | + 6 " " | 1,038 | 180,00 | 75,20 | 47,00 | 2,92 | - 16 |
| Leuna-Alkohol 100,000 + 7 Mol C ₂ H ₅ C | + Adipinsäure | 0,972 | 53,90 | 24,60 | 15,70 | 4,06 | - 49 |
| " | + 2 " " | 0,970 | 78,50 | 30,80 | 21,40 | 3,88 | - 53 |
| " | + 3 " " | 0,969 | 119,20 | 50,60 | 31,30 | 3,10 | - 55 |

57095

Versuche in der Kettenmaschine.

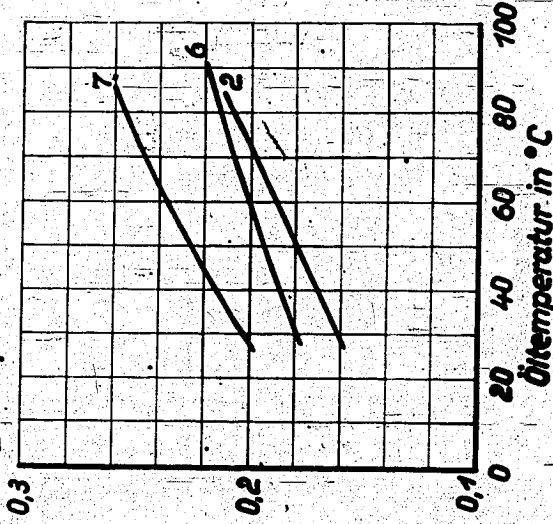
| | | | |
|-------------------------|---------------|------|-------------------|
| 1 = Adipinsäure | + n-Butanol | 1,23 | } E ₅₀ |
| 2 = " " | + n-Octanol | 1,51 | |
| 3 = " " | + n-Dodecanol | 2,06 | |
| 4 = β-Methyladipinsäure | + n-Octanol | 1,55 | |
| 5 = β- " " | + n-Dodecanol | 2,07 | |



Versuche in der Kettenmaschine.

- 2 = Adipinsäure + n-C₈-Alkohol (350)
- 6 = " " + i-C₈-Alkohol (350)
- 7 = Methyladipinsäure + i-C₈-Alkohol (303)

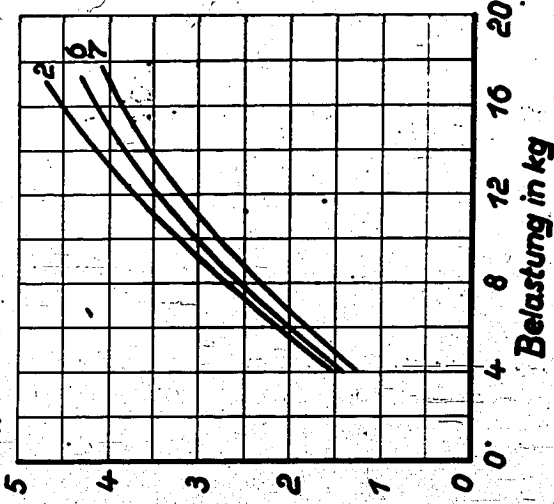
Reibungszahl μ



Verschleißversuche.

- Scheibe aus Hartmetall gegen Stahl
- Versuchsdauer 10 Min.
- Öltemperatur 20°C

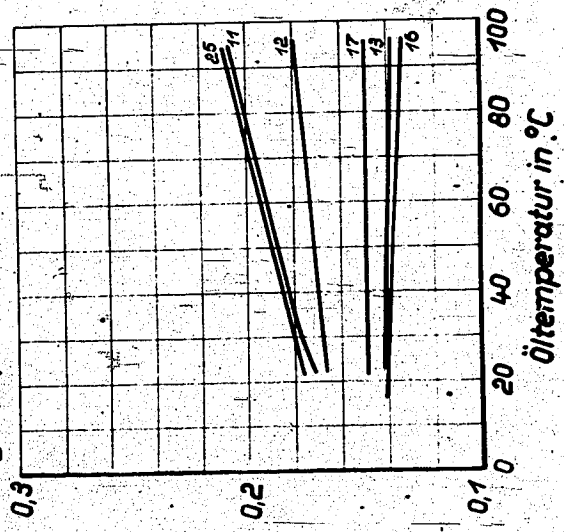
Ausschliff in mm³



Versuche in der Kettenmaschine.

- 25 = Trimethyläthan + Leuna-Carbonsäure 200/250
- 11 = " " + i-C₈-Säure
- 12 = " " + Vorlauf-Fettsäure C7-C9
- 13 = " " + 3 Mol i-C₁₃-Säure
- 17 = " " + 2 " " "
- 16 = Pentaerythrit + 4 " " "

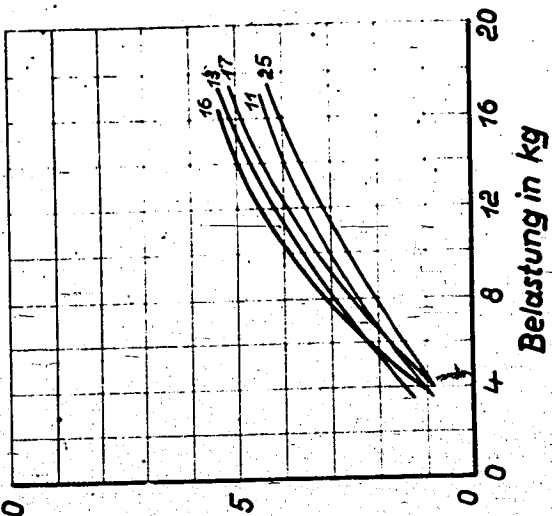
Reibungszahl μ



Verschleißversuche.

- Scheibe aus Hartmetall gegen Stahl
- Versuchsdauer 10 Min.
- Öltemperatur 20 °C

Ausschliff mm³

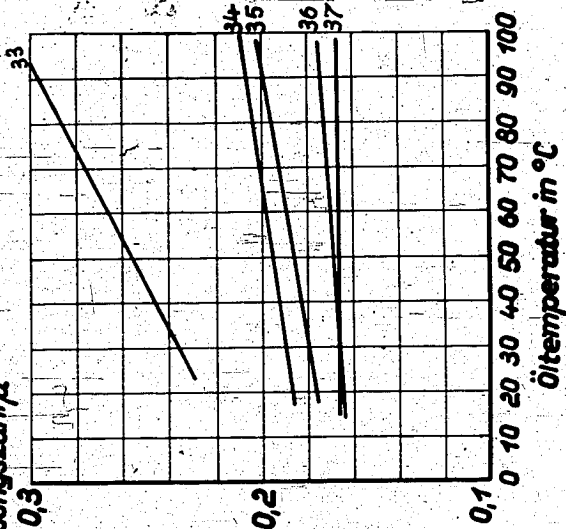


Versuche in der Kettenmaschine.

$iC_4-(OCH_2-CH_2)_x$ + Methyldipipinsäure

- 33: x = 0
- 34: x = 1
- 35: x = 2
- 36: x = 4
- 37: x = 6

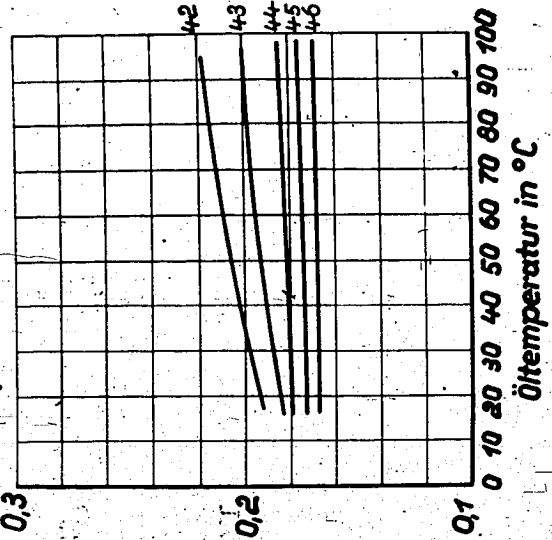
Reibungszahl/μ



42 = iC₉ Alkohol + 0 Mol C₂H₄O + Adipinsäure

- 43: " " + 1 " " + "
- 44: " " + 2 " " + "
- 45: " " + 4 " " + "
- 46: " " + 6 " " + "

Reibungszahl/μ



Haftarbeiten an verschiedenen Stoffen an Quecksilber (bei 22° C)
nach Messungen von K.L. Wolf und Dunker, Halle

| Stoff | Oberflächen-
spannung
(dyn/cm) | Grenzflächen-
spannung
(dyn/cm) | Haftarbeit
(erg/cm ²) |
|---------------------------|--------------------------------------|---------------------------------------|--------------------------------------|
| <u>Kohlenwasserstoffe</u> | | | |
| Hexan | 19,5 | 380 | 120 |
| Cyclohexan | 24,7 | 377 | 128 |
| Benzol | 28,6 | 366 | 143 |
| <u>Alkohole</u> | | | |
| Methanol | 22,5 | 384 | 119 |
| Aethanol | 22,4 | 382 | 120 |
| n-Propanol | 23,7 | 379 | 125 |
| i-Propanol | 23,7 | 384 | 117 |
| n-Butanol | 24,8 | 377 | 128 |
| i-Butanol | 20 | 384 | 116 |
| n-Hexanol | 26,4 | 372 | 134 |
| n-Octanol | 27 | 367 | 140 |
| <u>Säuren</u> | | | |
| Amisen- | 37,4 | 393 | 124 |
| Essig- | 27,4 | 331 | 176 |
| Propion- | 26,5 | 333 | 174 |
| n-Butter- | 26,6 | 335 | 172 |
| n-Valerian- | 27,4 | 333 | 174 |
| n-Hexyl- | 28,1 | 334 | 174 |
| n-Heptyl- | 28,3 | 335 | 173 |
| n-Octyl- | 28,7 | 334 | 175 |
| n-Nonyl- | 29,9 | 332 | 178 |
| <u>Ester</u> | | | |
| Methylacetat | 24,9 | 388 | 117 |
| Aethyl- | 23,8 | 384 | 120 |
| n-Propyl- | 24,3 | 380 | 124 |
| i-Propyl- | 23,1 | 369 | 134 |
| n-Butyl | 24,5 | 374 | 131 |
| sek-Butyl | 23,5 | 354 | 150 |
| i-Butyl | 22,8 | 355 | 148 |
| n-Amyl | 25,5 | 365 | 141 |
| i-Amyl | 24,8 | 345 | 160 |
| n-Hexyl | 26,3 | 365 | 141 |
| n-Heptyl | 27,1 | 357 | 150 |
| n-Decyl | 28,7 | 343 | 166 |
| n-Dodecyl | 29,1 | 341 | 168 |

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Unterschiede der Haftarbeiten an wässrigen und
metallischen Grenzflächen nach Messungen von
K.L. Wolf, Halle

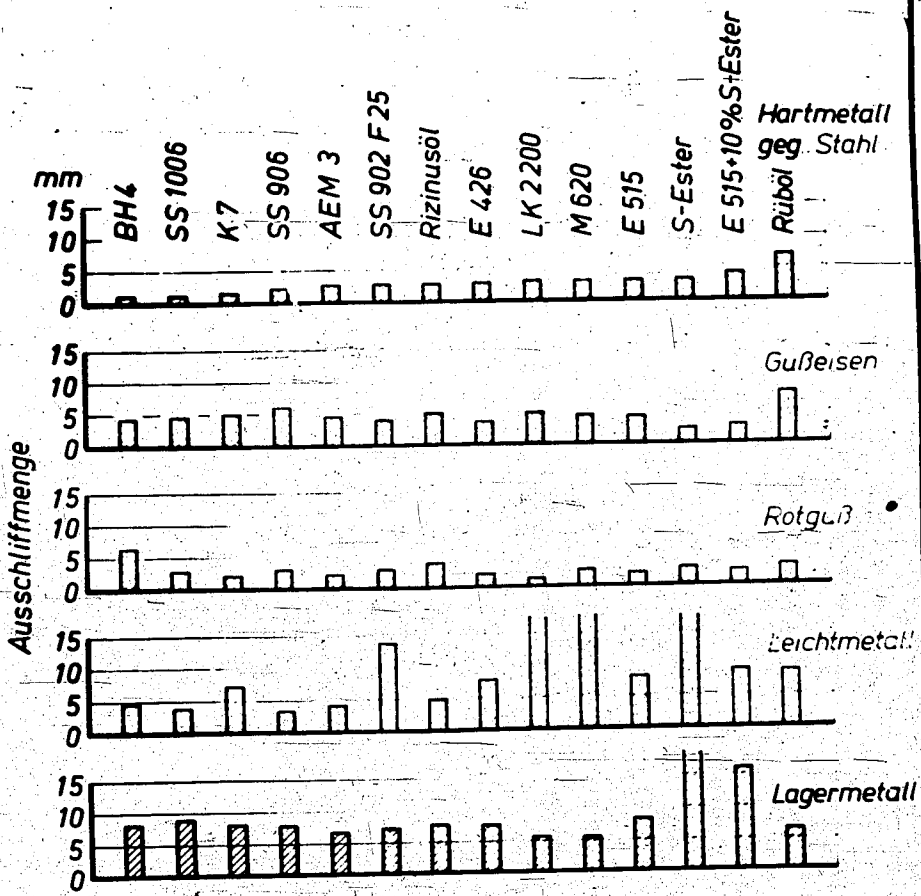
| S t o f f | Grenzflächenspannung
(dyn/cm)
gegen | | Haftarbeit H
(erg/cm ²)
gegen | |
|----------------------------------|---|-------------|---|-------------|
| | Wasser | Quecksilber | Wasser | Quecksilber |
| Hexan | 51,25 | 380 | 40,0 | 120 |
| Benzol | 35,03 | 366 | 66,6 | 143 |
| CCl ₄ | 43,26 | 358 | 56,1 | 149 |
| C ₆ H ₅ Cl | 37,41 | 350 | 68,5 | 163 |
| CS ₂ | 48,36 | 341 | 55,8 | 170 |
| Merkaptan | 26,12 | 340 | 68,5 | 160 |
| Oktanol | 8,52 | 367 | 90,8 | 140 |
| Heptylsäure | 6,56 | 335 | 94,6 | 173 |
| Ester | etwa 25 | etwa 350 | etwa 75 | etwa 150 |

57087

Zerreissfestigkeit und Haftfestigkeit nach Berechnungen
von K.L. Wolf, Halle

| S t o f f | Zerreissfestig-
keit Z
(kg/cm ²) | Haftfestigkeit
Z-haft
(kg/cm ²) |
|------------------|--|---|
| Cyclohexan | 4 900 | 12 500 |
| Benzol | 5 600 | 14 300 |
| CCl ₄ | 5 600 | 15 000 |
| Aethanol | 4 500 | 12 000 |
| Propanol | 4 700 | 12 500 |
| Butanol | 5 000 | 12 800 |
| Hexanol | 5 300 | 13 400 |
| Propionsäure | 5 300 | 17 400 |
| Buttersäure | 5 300 | 17 200 |
| Hexylsäure | 5 600 | 17 400 |
| Heptylsäure | 5 700 | 17 400 |
| Wasser | 14 400 | 16 700 |
| Quecksilber | 96 000 | 96 000 |
| Messing | 5 000 | |
| Linnen | 4 000-7 000 | |

57085.



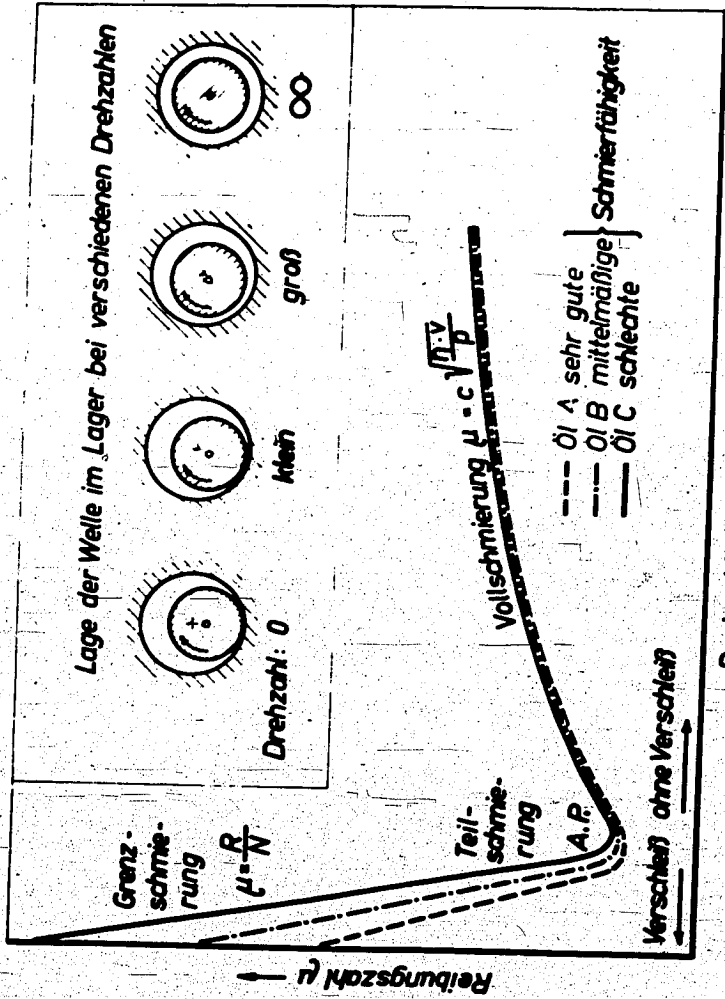
57123

IG
Ludwigshafen a. R.
1943

**Verschleiß verschiedener Metalle
bei Verwendung verschiedener Öle**

**Techn. Prüfstand
Oppau
1412**

74



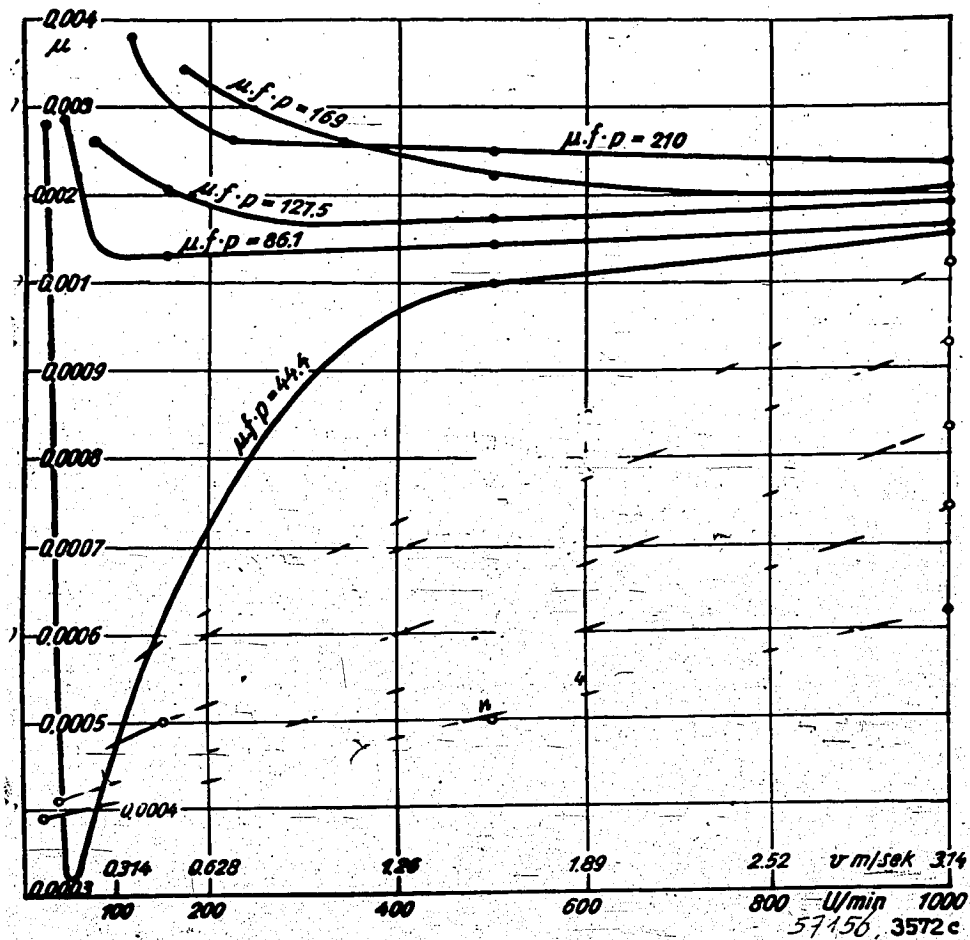
5123.

IG

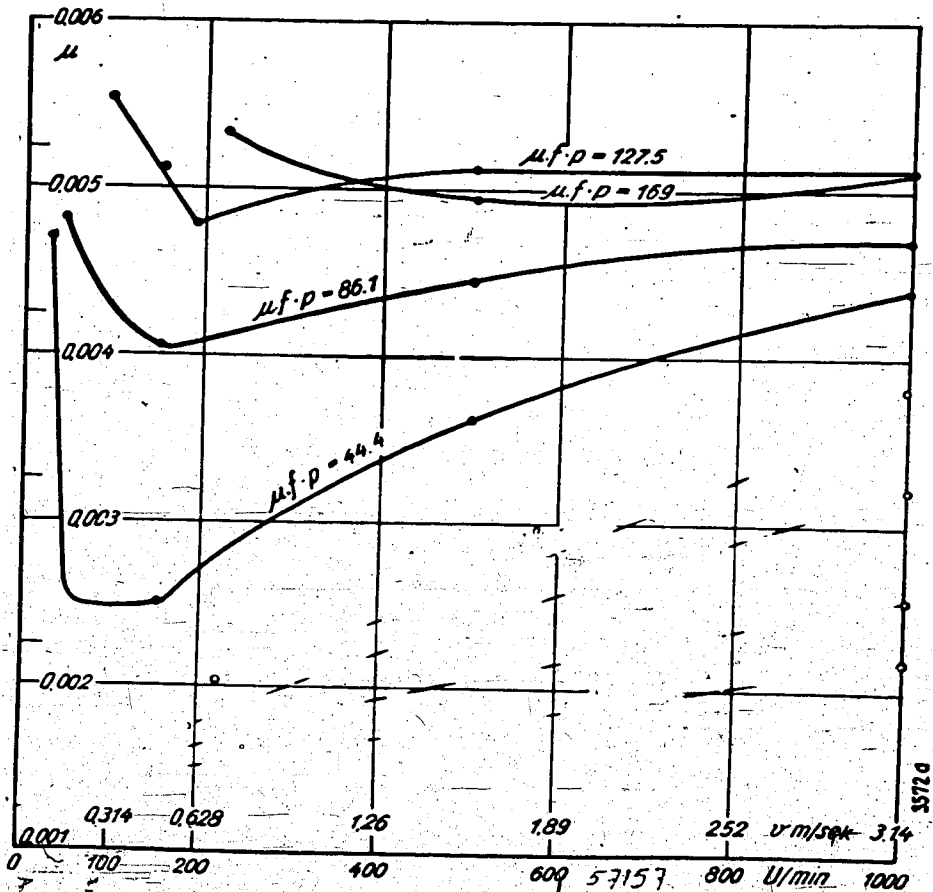
Ludwigschafhausen a. Rh.
1942

Schmierzustände im Gleitlager bei 3 Ölen gleicher Viskosität

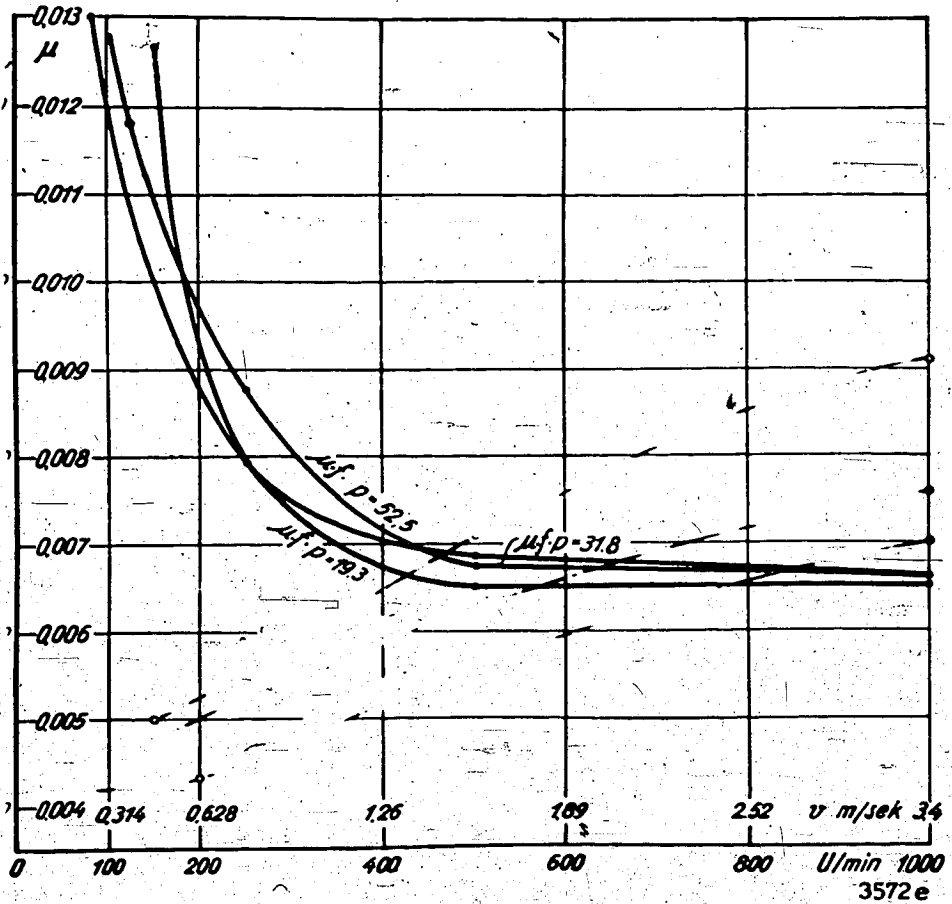
Techn. Prüfstand
Oppau
1180



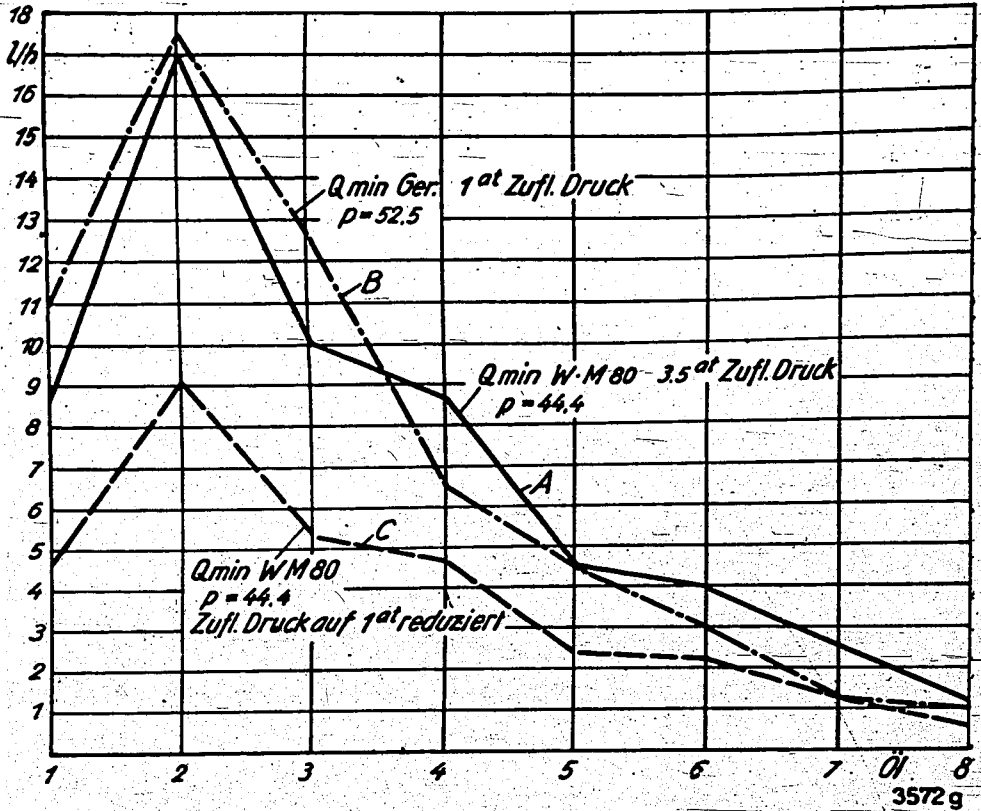
Legierung Weißmetall, 74 Pb, 14,9 Sb, 6,9 Sn, 2,0 Cd, 1,0 Cu, 1,3 Ni. Spiel 0,25 mm. Oldruck 3,5 at. Öldruck 30° C. Öl BC 8
 ————— Reibungswerte „ ———— Temperaturen im Ölfilm



Legierung Weißmetall, 81,63 Pb, 14 Sb, 0 Sn, 3,07 As, 0,98 Cu, 0,01 Ni. Spiel 0,25 mm. Öldruck 3,5 at. Öltemperatur 30° C. Öl BC 8



Buchse aus Kunstharz-Preßstoff Typ T₂, Textilfüllung. Öl BC 8.
 Öldruck 1 at. Öltemperatur 30° C. Spiel 0,25 mm. 57158



Vergleich der Öldurchlässigkeit zweier Lagerschalen aus WM 80 und Kunstharz-Preßstoff

Kurve A: WM 80. Öldruck 3.5 at. Öltemperatur 30° C. $p = 44.4$.

Kurve B: Kunstharz-Preßstoff. Öldruck 1 at. Öltemperatur 30° C, $p = 52.5$

Kurve C: WM 80. Öldruck red. auf 1 at.

Ölmenge gemessen bei 8 Ölen verschiedener Zähigkeit

57159

3572g