

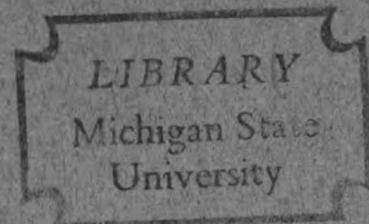


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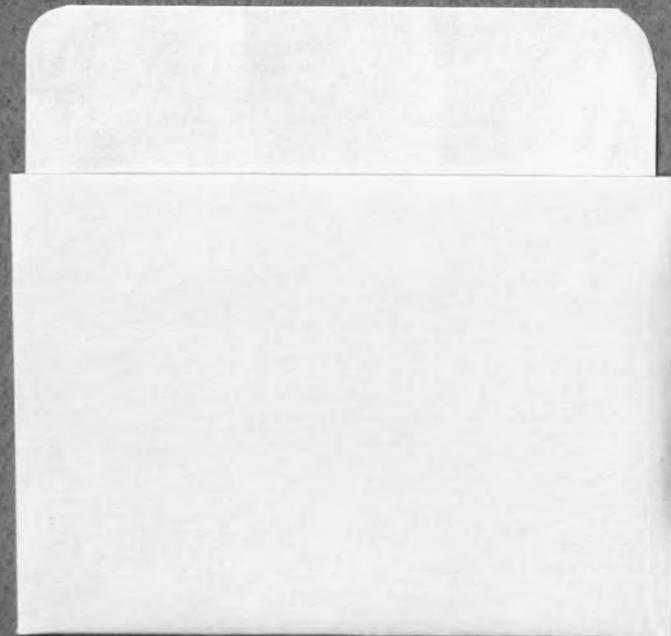
CONDENSATION OF SOME TERTIARY
OCTANOLS WITH PHENOL IN
THE PRESENCE
OF ALUMINUM CHLORIDE

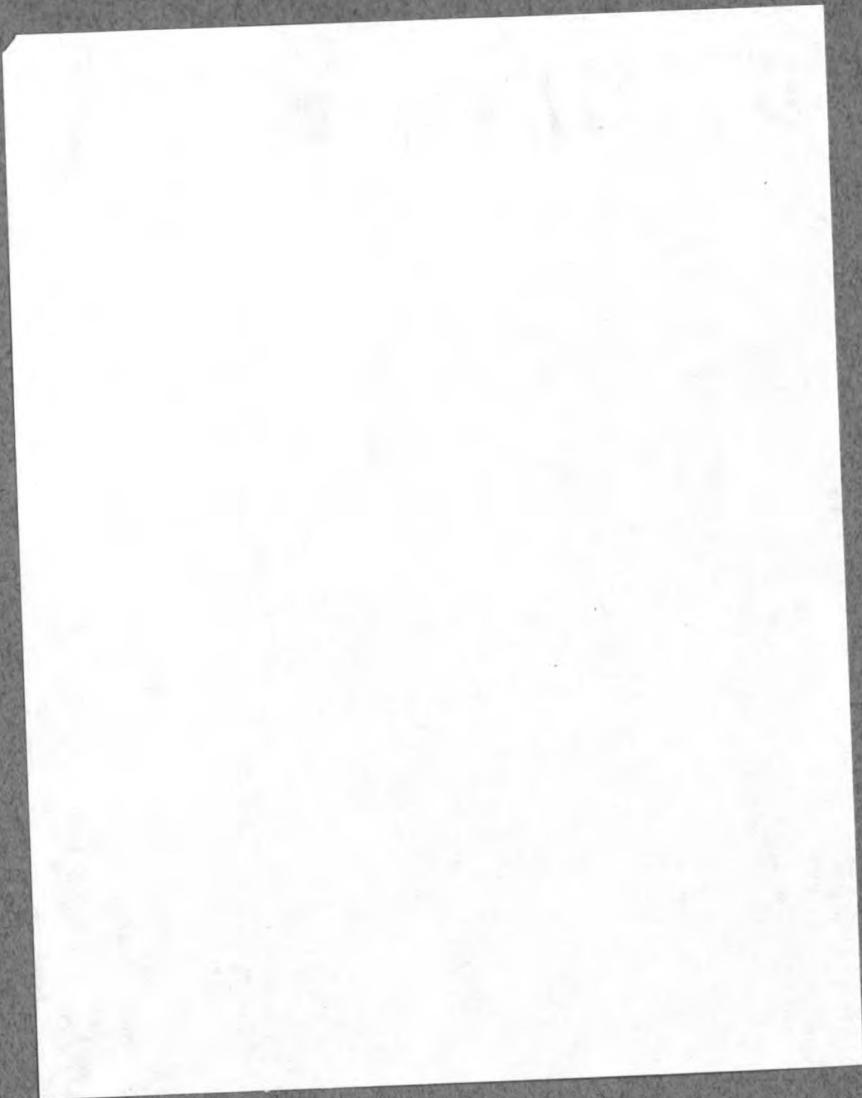
Thesis for the Degree of M. S.
James Edward Anderson
1936

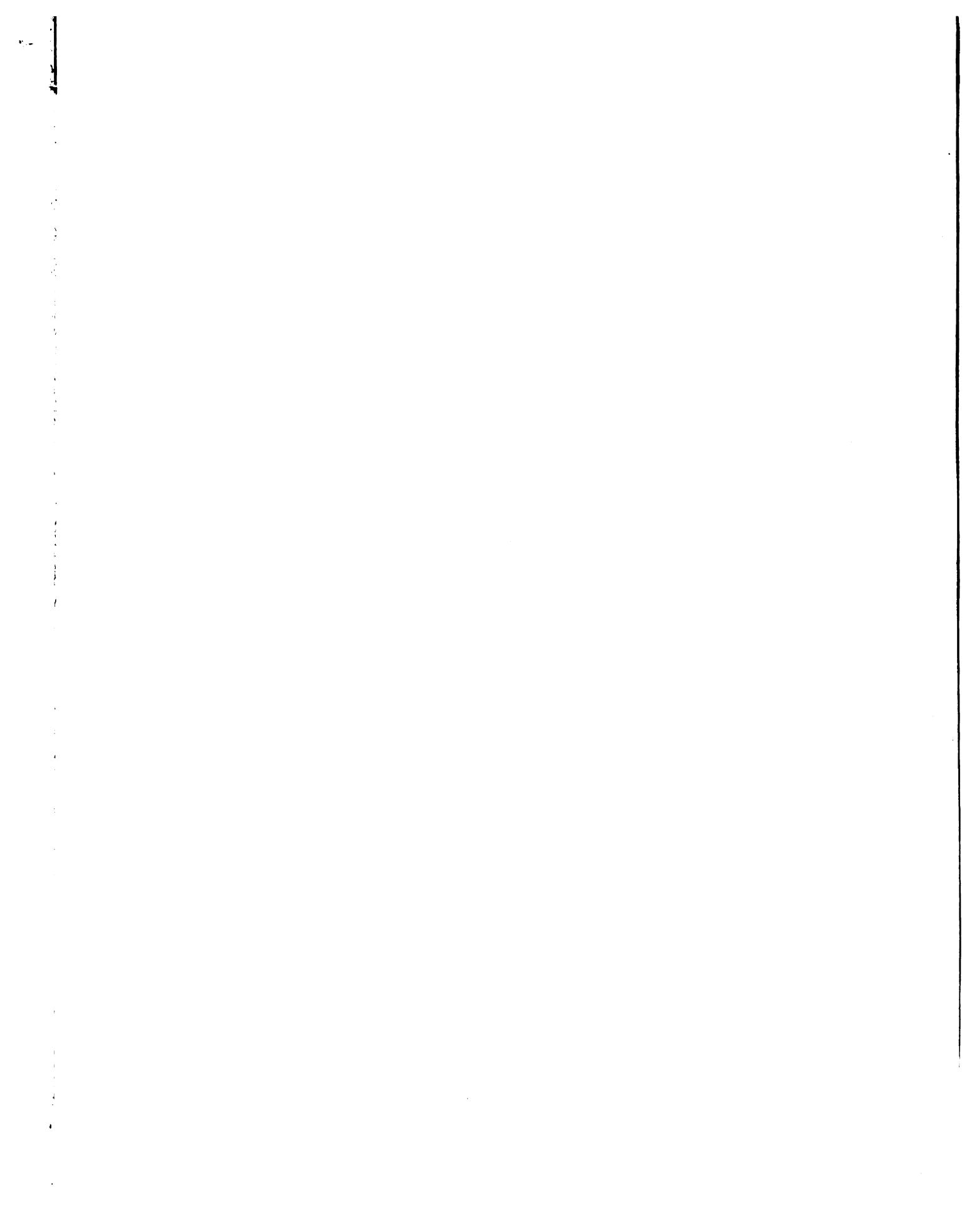
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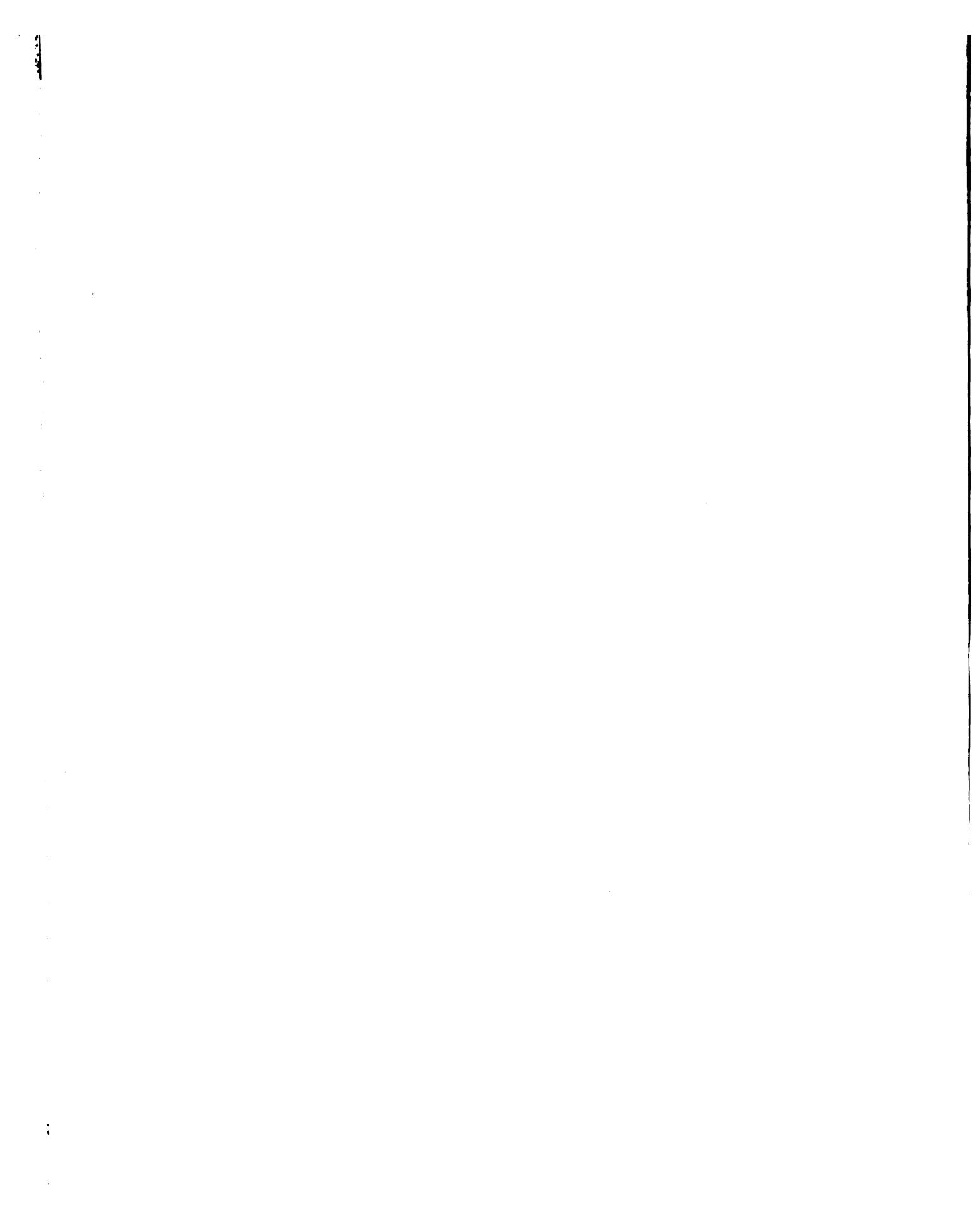


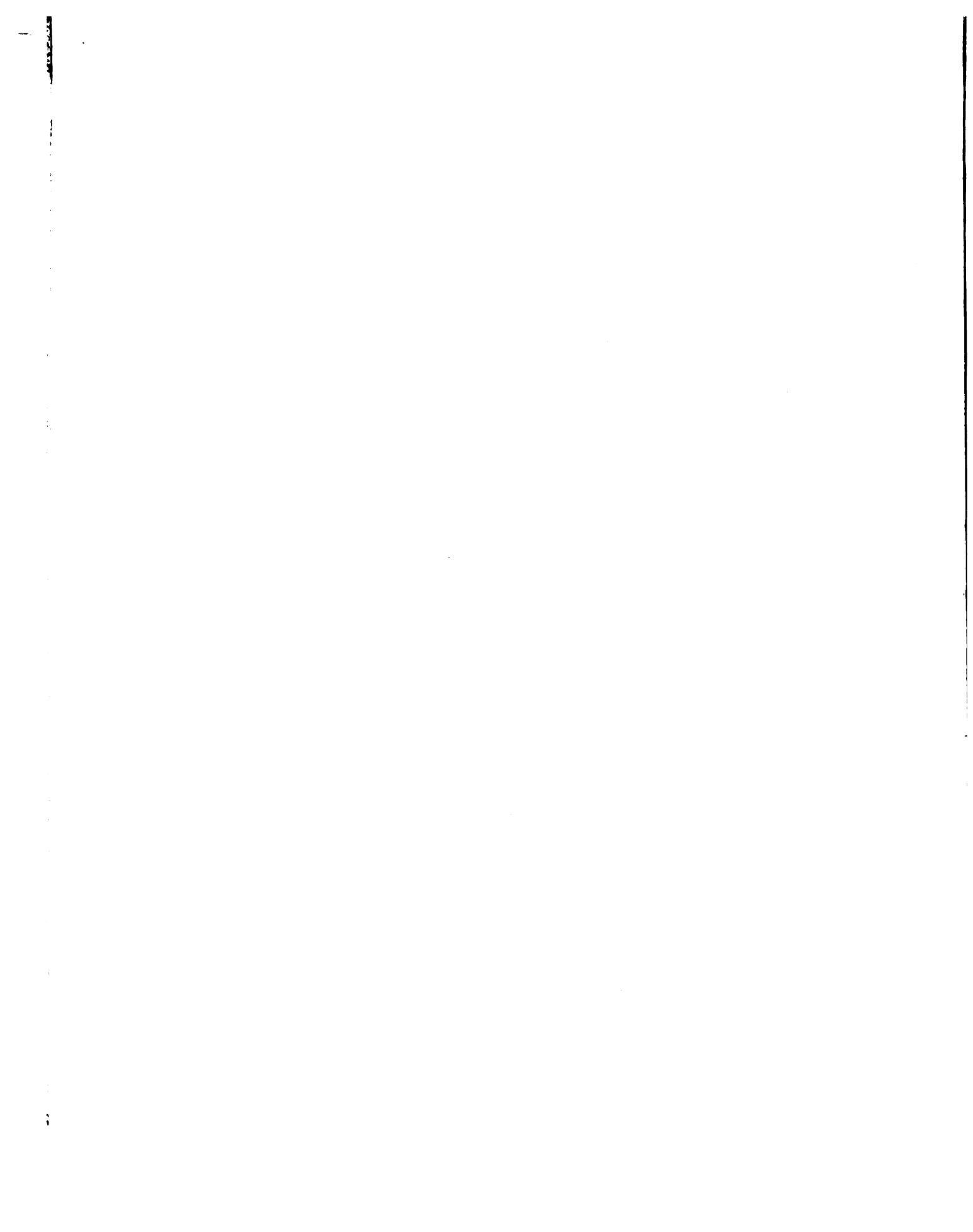
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CONDENSATION OF SOME
TERTIARY OCTANOLS WITH
PHENOL IN THE PRESENCE
OF ALUMINUM CHLORIDE

A Thesis

Submitted to the Faculty of Michigan
State College of Agriculture and Applied
Science in partial fulfillment of the re-
quirements for the Master of Science Degree

By

James Edward Anderson

August 1936

ACKNOWLEDGEMENT

The author gratefully acknowledges
his indebtedness to Dr. R. C. Huston
for his advice and guidance during
the performance of this work.

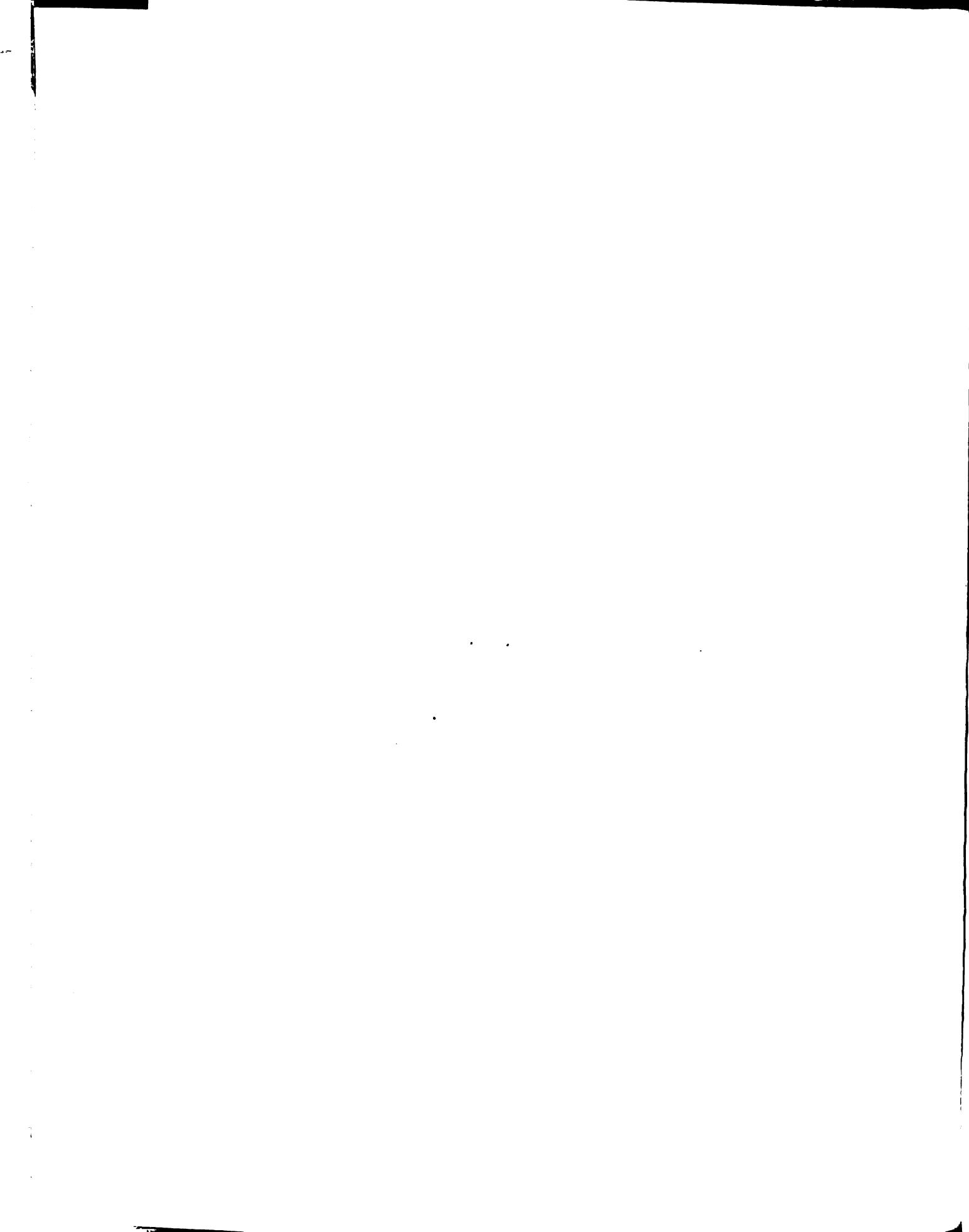
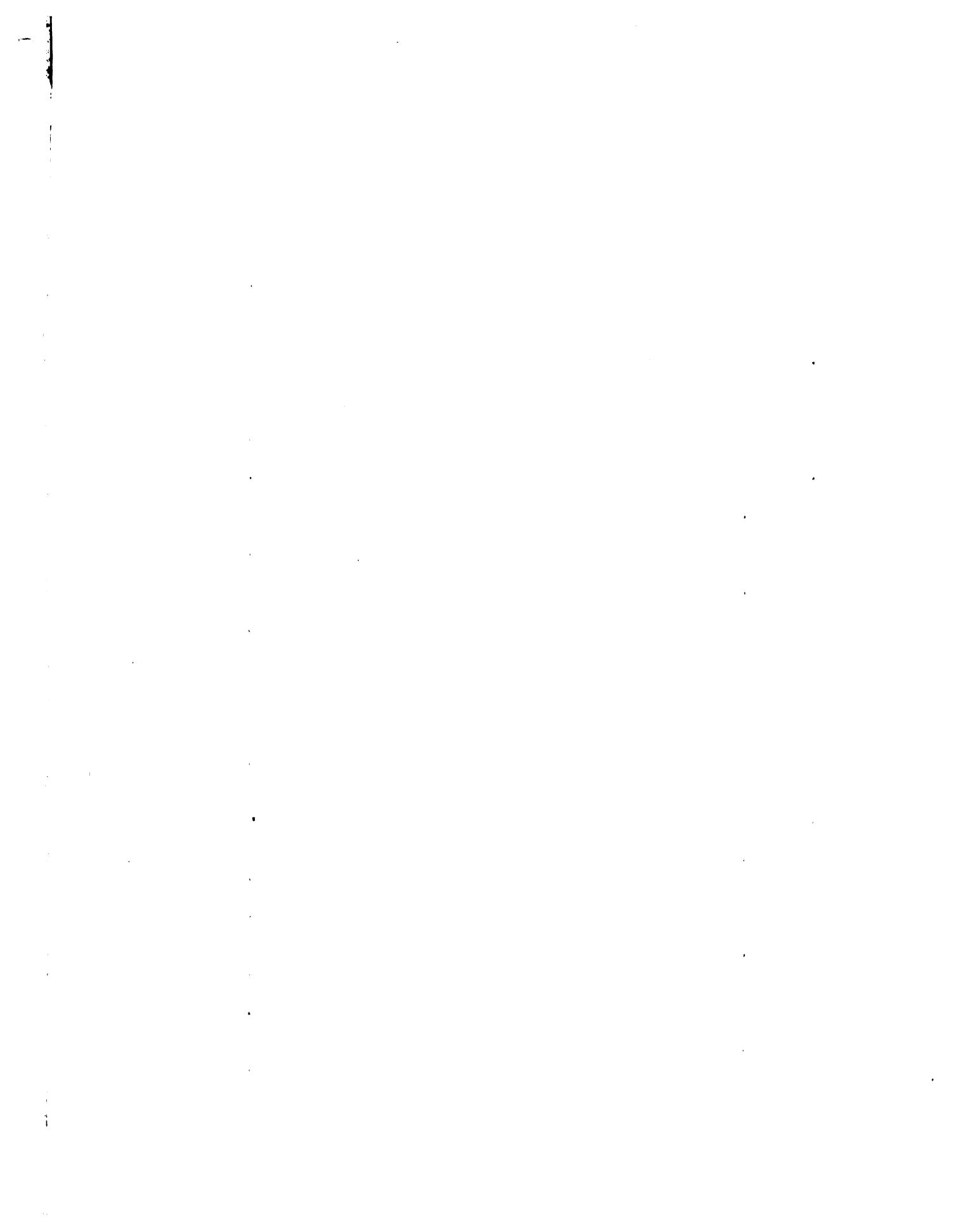


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HISTORICAL

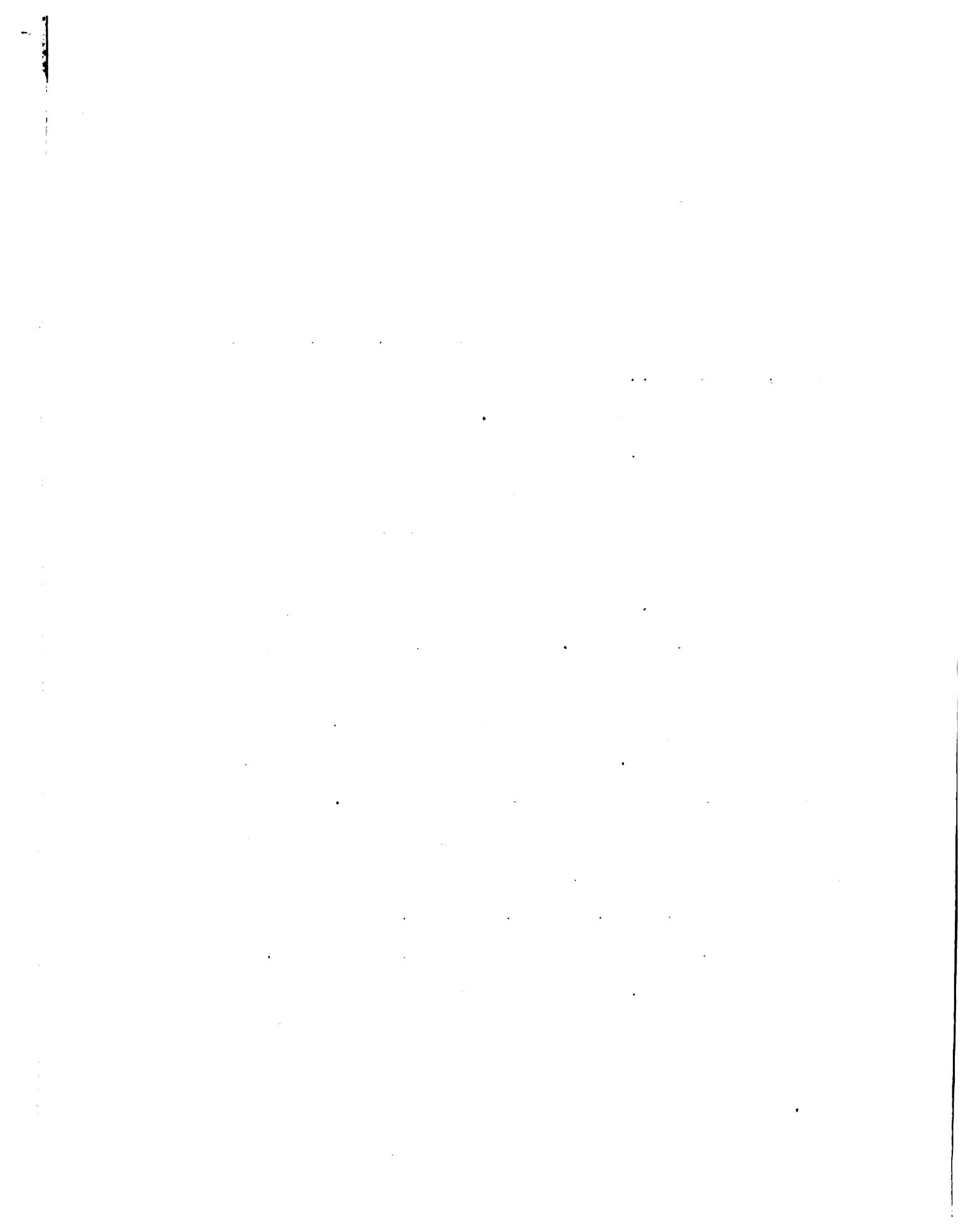
, Condensation of Alcohols and Benzeneas

A review of condensation reactions brought about by such catalysts as H_2SO_4 , H_3PO_4 , P_2O_5 , $ZnCl_2$, $MgCl_2$, PCl_5 , etc., has already been covered by previous workers in this laboratory (1).

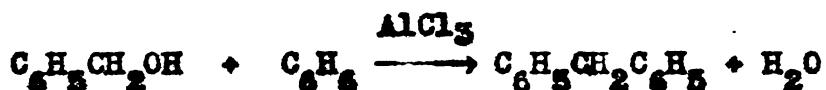
However, since this laboratory pioneered in the use of aluminum chloride as a condensing agent and since the problem of this thesis is a continuation of the research in the use of aluminum chloride as a condensing agent, it is well to review the foundation work done in this field. The condensations involved reactions of alcohols with either benzene or phenol or their homologues in the presence of aluminum chloride as a catalyst. The alcohols included aromatic, aliphatic and mixed aromatic aliphatic ones.

Aluminum chloride has been used as a dehydrating agent in organic chemistry by Merz and Weith, Sholl and Seer, Wass, Graebe, Joubert, Frankforter and Kritchensky, Frankforter and Kekatmir, and others.

However, Huston and Friedmann present the first recorded condensation of aromatic alcohols and aromatic compounds in the presence of aluminum chloride (2).



When benzyl alcohol was mixed with a little more than its molecular equivalent of benzene, and the mixture treated with anhydrous AlCl_3 , a vigorous reaction resulted, with heat and HCl being liberated and the mixture becoming dark and pasty.



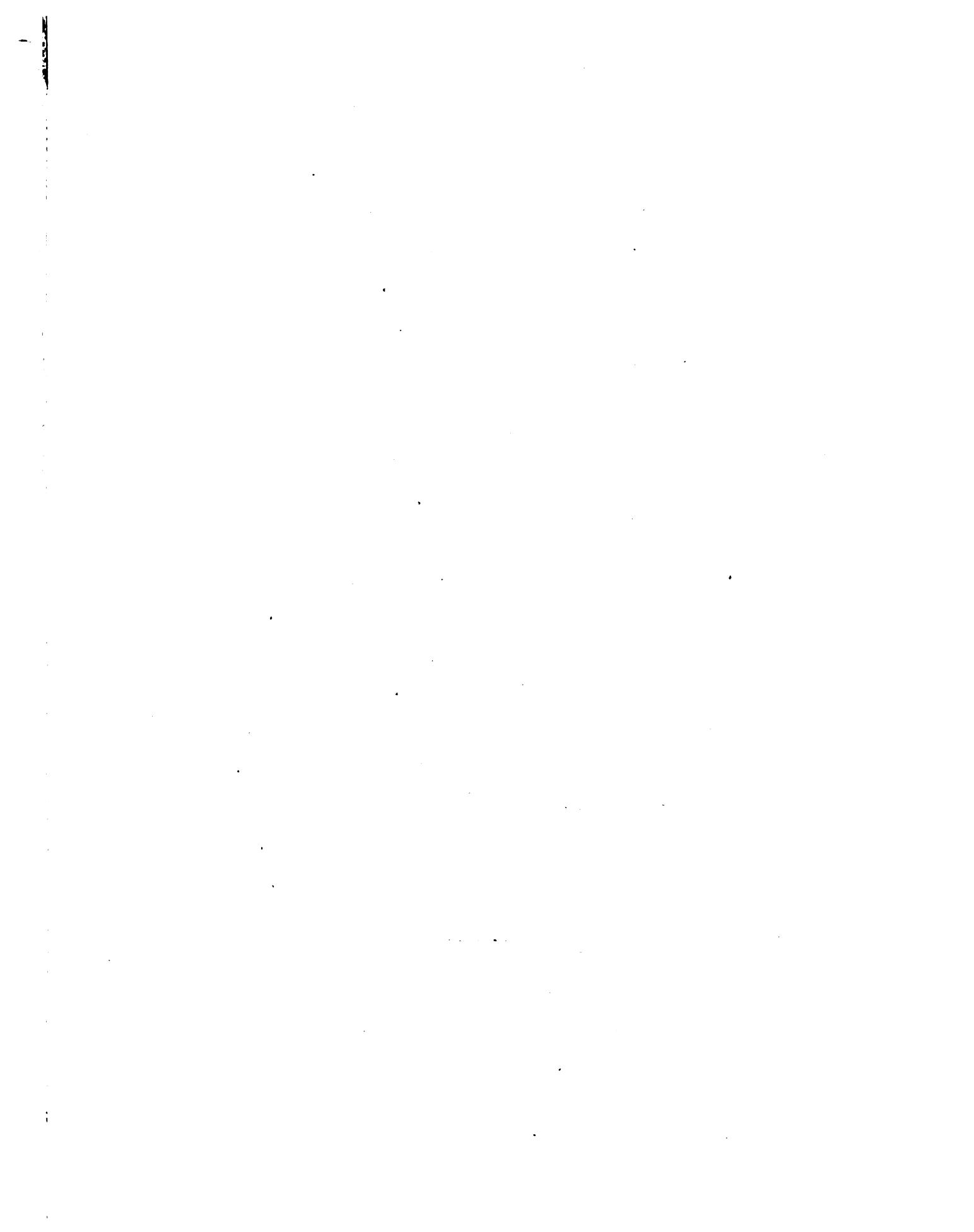
The yields of the products are greatly affected by the amounts of the reagents used and by the temperature at which the reaction is carried out. In one experiment where the temperature was kept below 35° and a large excess (5.2 moles) of benzene used, the diphenylmethane almost equalled in weight the benzyl alcohol used.

This historical preparation is essentially the method used in the condensations today.

Huston and Friedmann continued their work, condensing secondary aromatic alcohols with benzene (3). Mixed aliphatic-aromatic secondary alcohols and true aromatic secondary alcohols condensed successfully. Thus benzhydrol gave a good yield of triphenyl methane.



Huston and Sager (4) attempted to condense the primary alcohol, phenyl ethyl alcohol, with benzene in the presence of AlCl_3 . The results were negative.



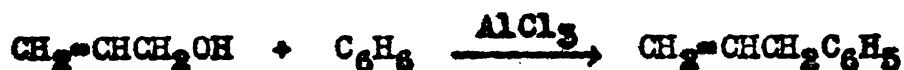
so far as the production of symmetrical diphenyl ethane was concerned.

Experiments thus far indicated that only those alcohols having the hydroxyl attached to a carbon adjacent to a ring carbon condense.

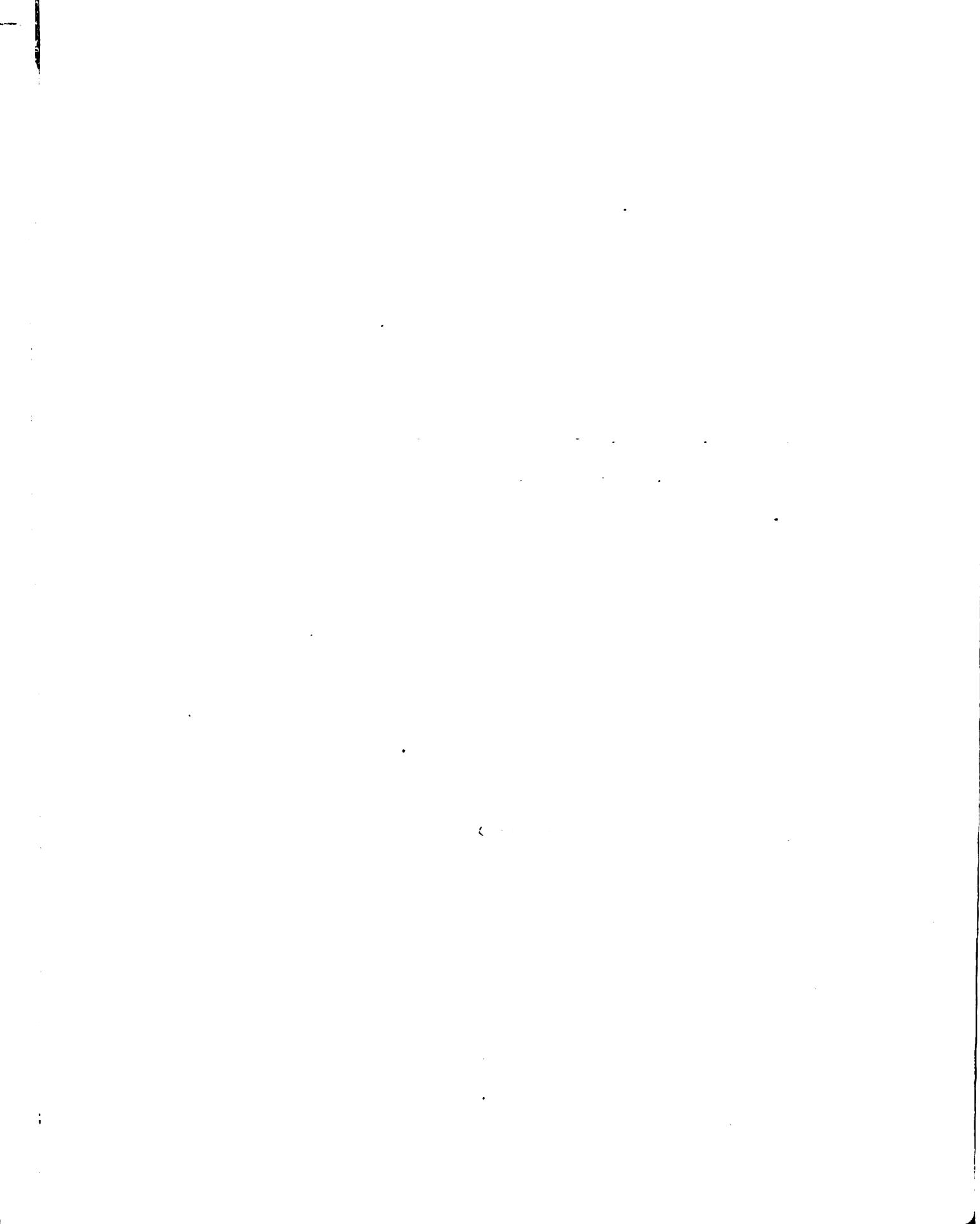
This generalization was substantiated when the same workers found that the primary alcohols, methyl, ethyl, propyl, n-butyl and iso-amyl, and the secondary alcohol, iso-propyl, failed to condense with benzene.

The possibility of condensing the hydroxyl attached to a carbon adjacent to an unsaturated group other than the benzene ring was next considered.

Huston and Sager (4) condensed allyl alcohol with benzene in the presence of AlCl_3 at room temperature. Allyl benzene was the principal product.



Huston and Gootemoot (5) showed that in condensation reactions with benzene in the presence of AlCl_3 the cycloalkyl carbinols show a progressive increase in activity as the number of carbon atoms of the ring is reduced from six to four, or as the strain on the carbonyl carbon is increased.



Huston and Wilsey (6) found that 1,1 di-phenyl ethyl carbinol reacted with benzene to give dehydration instead of condensation. 1,1 diphenyl -1-propene was the product obtained.

Likewise, Huston and Hradel (7) and Huston and Macomber (8) found that neither diaryl-alkyl carbinols nor dialkyl-aryl carbinols condensed with aluminum chloride. Instead, dehydration occurred. Huston and Fox (1) condensed tert-butyl alcohol, tert-amyl alcohol, dimethyl n-propyl carbinol and dimethyl iso-propyl carbinol with benzene to obtain tert-butyl benzene, tert-amyl benzene, dimethyl n-propyl phenyl methane and dimethyl iso-propyl phenyl methane.

Huston and Binder (9) condensed dimethyl n-butyl carbinol, dimethyl iso-butyl carbinol, dimethyl sec-butyl carbinol, dimethyl tert-butyl carbinol, methyl ethyl n-propyl carbinol, triethyl carbinol and methyl ethyl iso-propyl carbinol with benzene in the presence of aluminum chloride. Good yields of the tertiary alkyl benzenes were obtained.

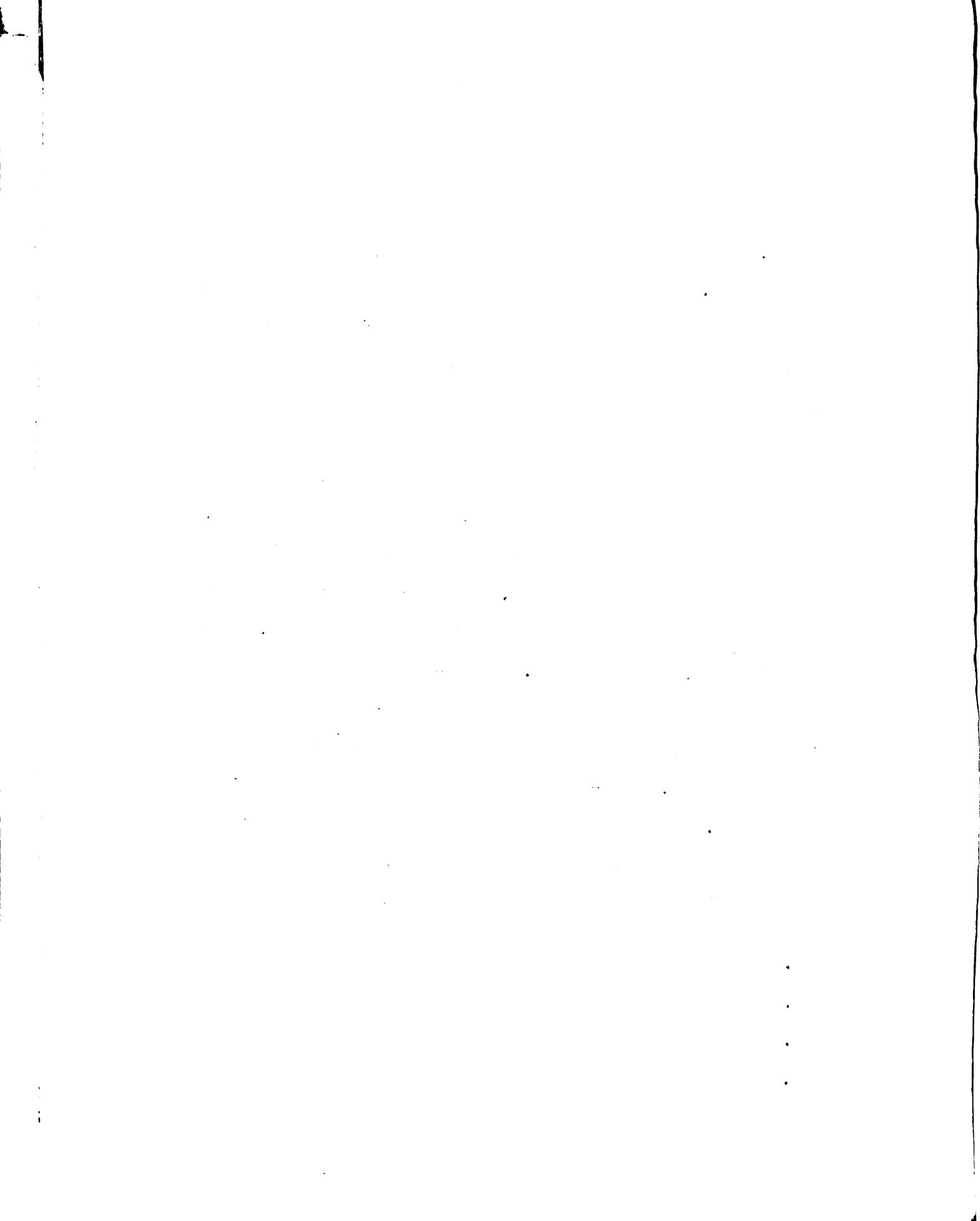
Huston and Hsieh (10) condensed secondary and tertiary aliphatic alcohols with benzene, obtaining the alkyl benzenes. The tertiary alcohols gave the best results and were condensed also with toluene, m-xylene, m-cresyl methyl ether and anisole.

Huston and Sculati (11) condensed tertiary heptanols with benzene in the presence of aluminum chloride. Good yields of the tertiary alkyl benzenes were obtained.

Tzakervanik (12) criticized Huston and co-workers for concluding that only alcohols with the OH group closely situated to a double bond are capable of forming condensation products with aromatic hydrocarbons in the presence of anhydrous aluminum chloride, and that the condensation is brought about by a cleavage of water. Tzukervanik found that benzene and toluene are easily alkylated by tertiary alcohols. Similar results were obtained by a condensation of the secondary alcohol, iso-propyl alcohol, with benzene. (Note— This research has already been carried out by Huston and co-workers with similar results, with the exception of the iso-propyl alcohol research. Iso-propyl alcohol did not condense with benzene.)

Using tert-amyl alcohol, Tzukervanik explains the condensation with benzene as follows:

1. $\text{AmOH} + \text{AlCl}_3 \longrightarrow \text{AlCl}_2\text{OAm} + \text{HCl}$
2. $\text{AlCl}_2\text{OAm} \longrightarrow \text{C}_5\text{H}_{10} + \text{AlCl}_2\text{OH}$
3. $\text{C}_5\text{H}_{10} + \text{HCl} \longrightarrow \text{AmCl}$
4. $\text{AmCl} + \text{C}_6\text{H}_6 \longrightarrow \text{AmC}_6\text{H}_5 + \text{HCl}$



The last reaction is a typical Friedel and Crafts reaction. Equation 1 involves the replacement of the difficultly replaceable hydrogen of the hydroxyl of a tertiary alcohol which is questionable.

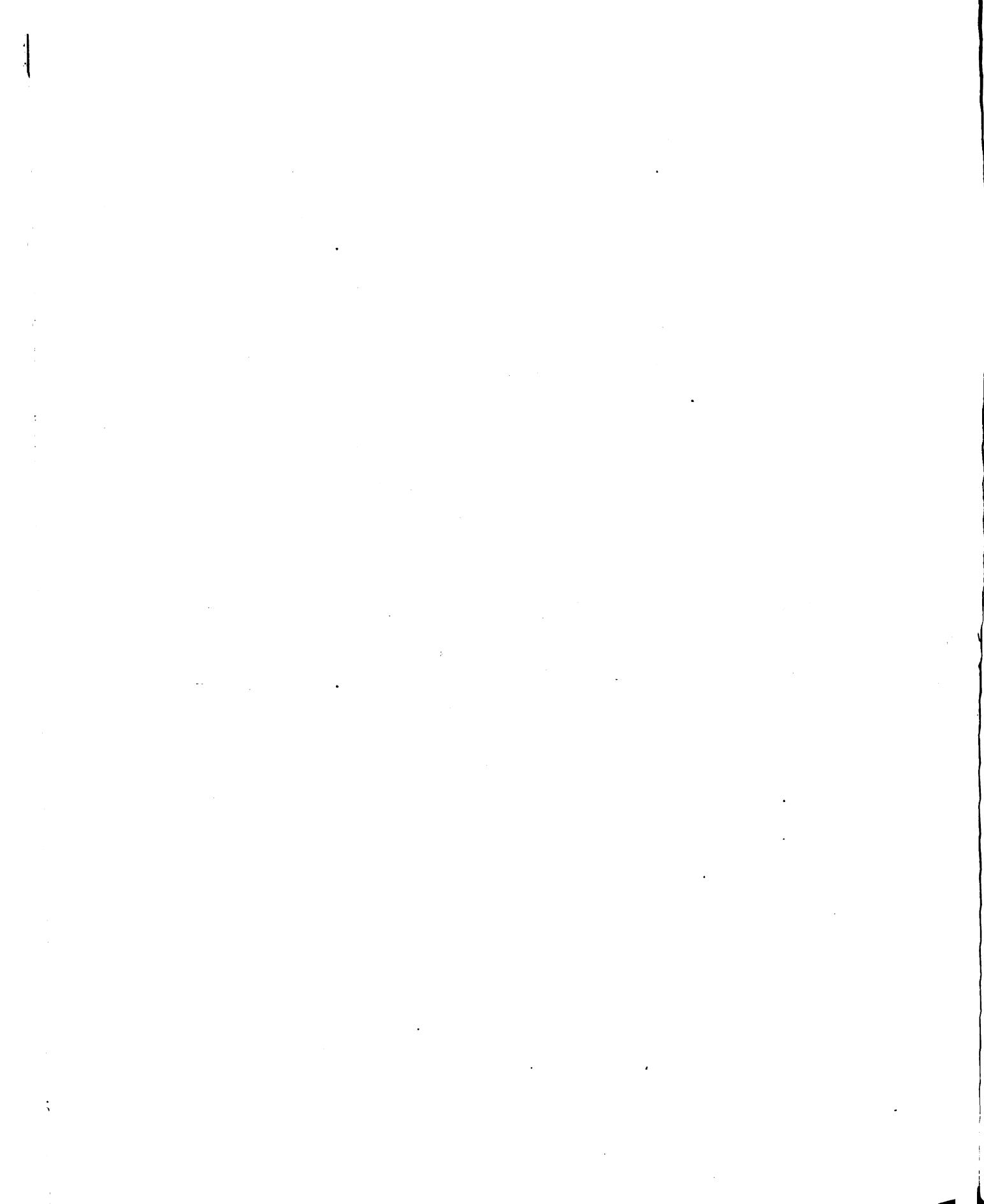
Kashtanov (13) showed that aluminum chloride and thallium chloride could be used interchangeably in bringing about the condensation of an alkyl chloride with benzene.

Summary

In general we can conclude from the work thus far that alcohols in which the hydroxyl group is activated, condense with the benzene and its homologues in the presence of anhydrous aluminum chloride. The hydroxyl may be activated because the alpha carbon is double bonded or is a member of the benzene or cyclo-alkane ring. It may be activated by being attached to a tertiary, aliphatic carbon or in some cases to a secondary carbon atom.

Condensation of Alcohols with Phenols

A review of the various methods of preparing alkyl phenols is given by Hsieh (10). These need not be repeated here. However, since this research is a continuation of the condensation of aromatic and aliphatic alcohols with phenol in the presence of aluminum



chloride, the work in this field is reviewed.

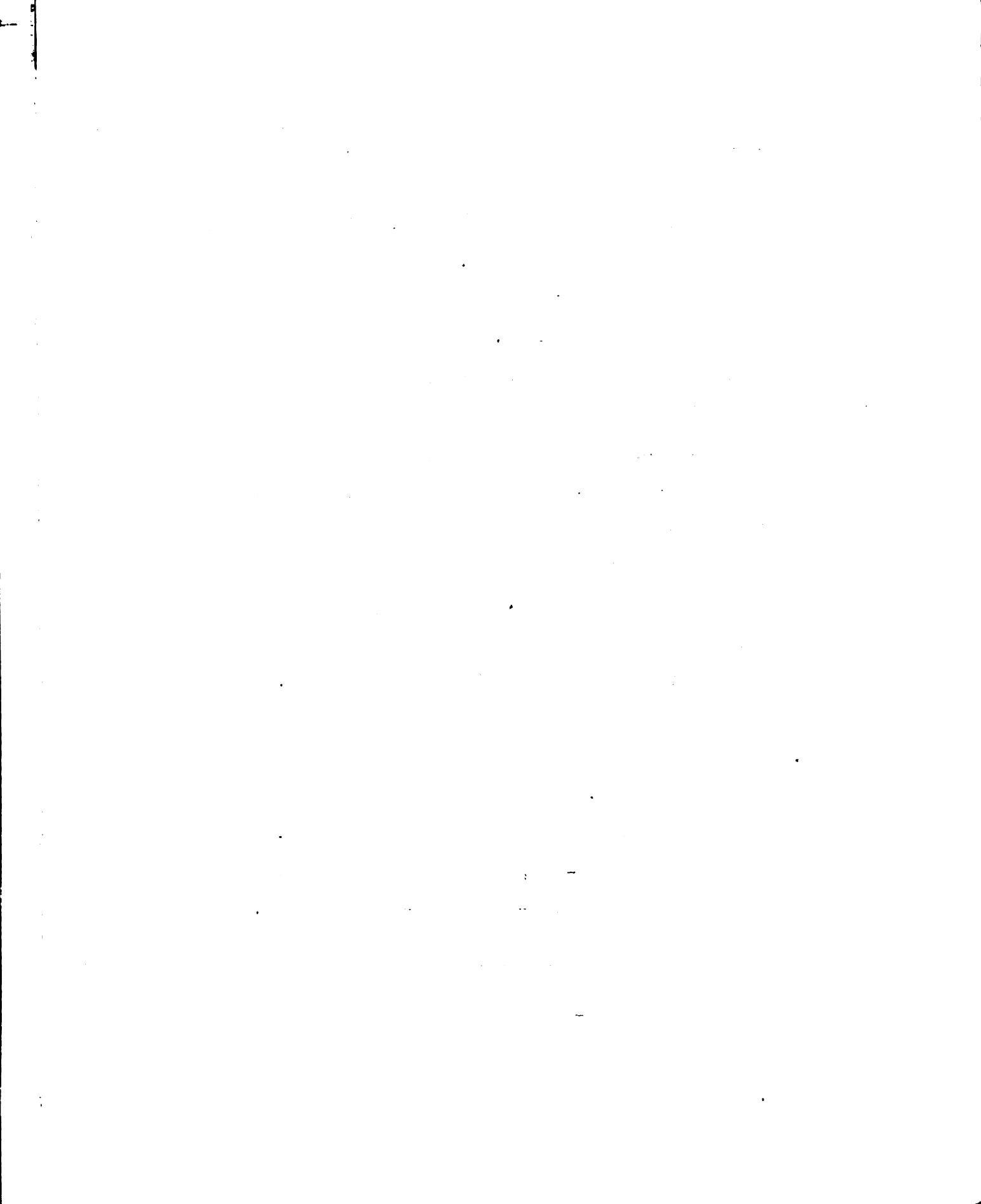
The condensation of benzyl alcohol and phenols has been accomplished by the use of zinc, sulphuric acid, acetic acid and zinc chloride (14). Zinc and zinc chloride have also been used in the condensation of simple aliphatic alcohols with phenols.

Although Marx and Weith (15) found that aluminum chloride reacted with phenol to give a 10% to 12% yield of diphenyl ether when the mixture is heated under a reflux condenser, Huston and others (14) find that the diphenyl ether is not formed to an appreciable extent if the phenol is suspended in petroleum ether and the temperature kept below 50°.

In the condensation of phenols and alcohols in this laboratory the Huston method was used (14). When a mixture of one molecular equivalent of benzyl alcohol and 1.1 equivalents of phenol was suspended in petroleum ether and treated with .5 molecular equivalent of anhydrous aluminum chloride, a vigorous reaction occurred. By decomposition of the dark-red, intermediate product, there was obtained a good yield (43-45%) of p-benzylphenol.



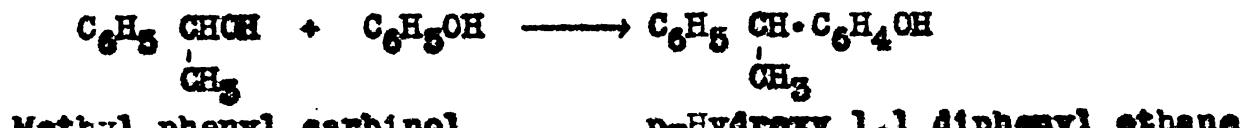
The yield of p-benzylphenol was not increased by the use of a full molecular equivalent of aluminum chloride. When petroleum ether was omitted the reaction



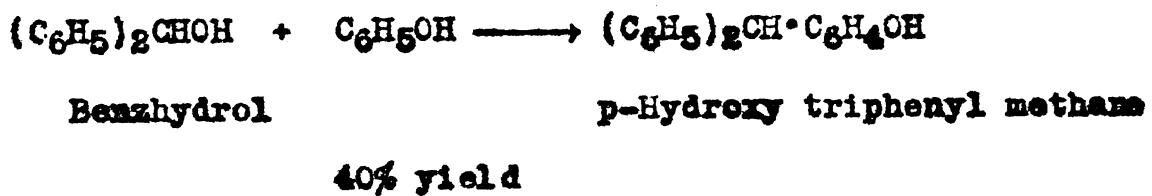
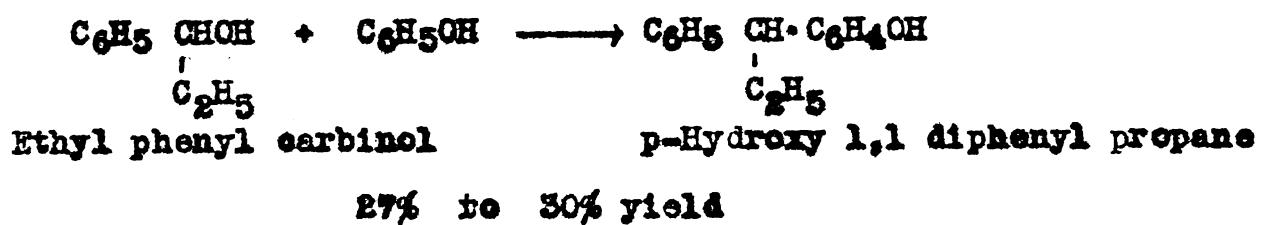
started more slowly. Then the temperature rose rapidly to 65°. The yield of p-benzylphenol was reduced. Carbon disulphide can be used in place of petroleum ether.

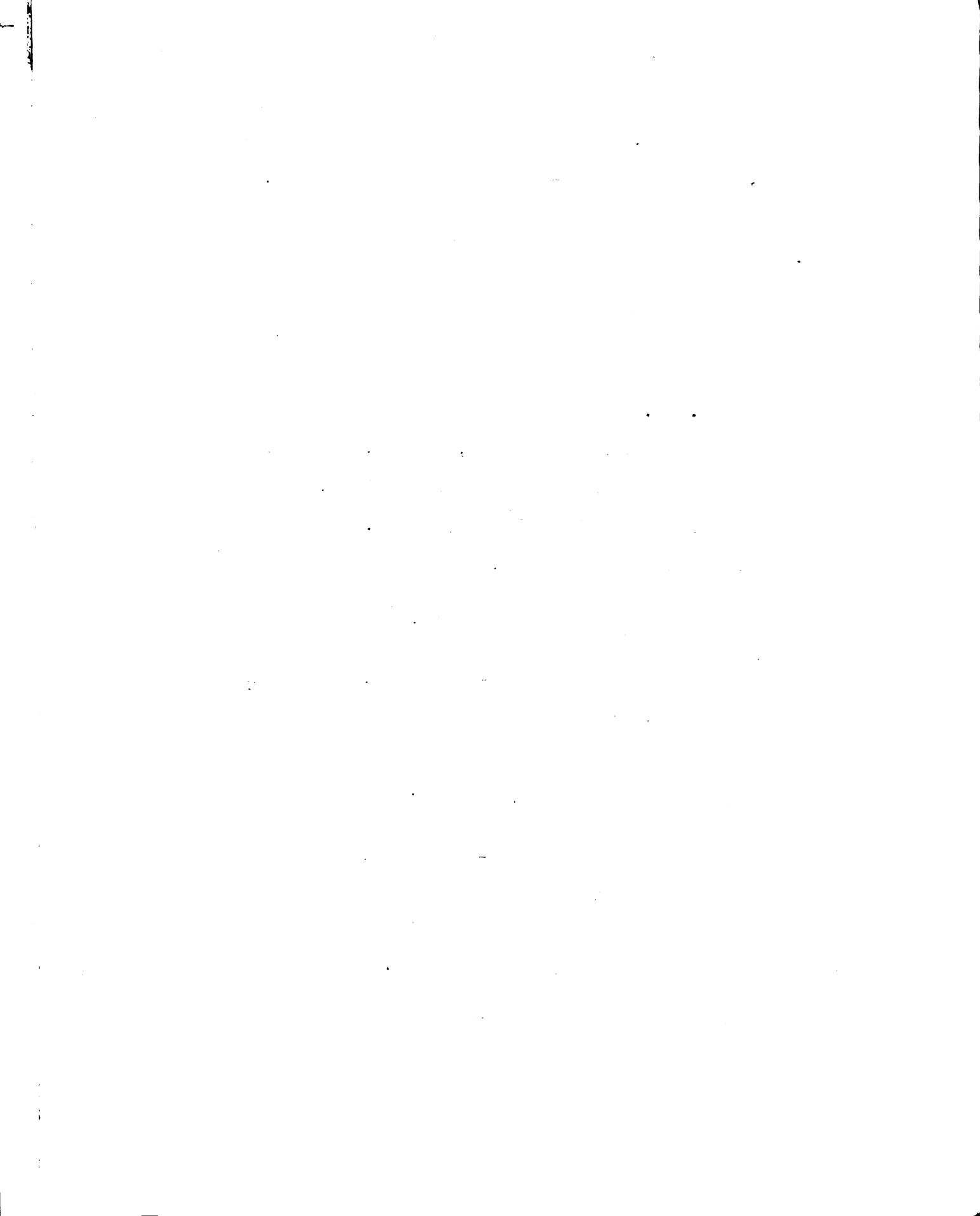
The condensation of benzyl alcohol with anisole and phenetole took place even more readily, with the formation of the methyl and ethyl ethers of p-benzylphenol(14).

Using the same technique, Huston, Lewis and Grotewat (16) condensed methyl phenyl carbinol, ethyl phenyl carbinol and benzhydrol with phenol. The following results were obtained:

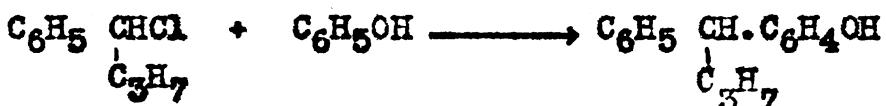
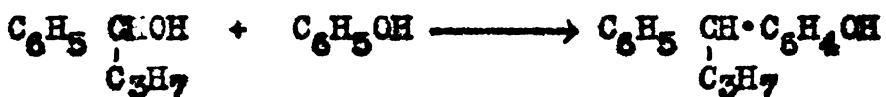


33% to 35% yield





Huston and Strickler (17) condensed phenyl propyl carbinol and α -chloro-butyl benzene with phenol to yield chiefly 4(α -phenyl-butyl) phenol.



This was further indication that the chloride and alcohol act similarly in the condensation reaction.

Huston, Swarthout and Wardell (18) benzylated α -cresol by condensing benzyl alcohol with α -cresol in the presence of aluminum chloride. The main product was 2 methyl 4 benzyl phenol. Smaller amounts of 2 methyl 6 benzyl phenol and 2 methyl 4,6 dibenzyl phenol were formed.

Huston and Lewis (19) condensed p -cresol and benzyl alcohol with aluminum chloride. A 35% yield of 2 benzyl 4 methyl phenol, and a 36% yield of 4 methyl 2,6 dibenzyl phenol were obtained.

Huston and Houk (20) benzylated m -cresol by the condensation reaction. 3 methyl 4 benzyl phenol and 3 methyl 4,6 dibenzyl phenol were obtained.

Huston and Newmann (21) reported the condensation of allyl alcohol with phenol in 1933.

Huston and Hsieh (22) found that the primary aliphatic alcohols, ethyl, propyl and butyl, did not condense with phenol in the presence of aluminum chloride. Iso-propyl alcohol reacted with phenol to give an unidentified product. Sec-butyl alcohol did not react. Tertiary aliphatic alcohols were found to condense readily with phenol to give para alkyl phenols. The structure of these phenols was proved by condensing the alcohol with benzene. The alkyl benzene was nitrated, reduced, diazotized and hydrolyzed to give the phenol. The alkyl nitrobenzene was oxidized in a Carius bomb to p-nitrobenzoic acid. In these condensations a technique similar to that employed in the condensation of aromatic alcohols and phenols was used.

Summary

When the hydroxyl group of an alcohol is activated by having the alpha carbon attached to a double bond or be a member of the benzene ring, condensation with phenol or its homologues in the presence of aluminum chloride occurs. When the hydroxyl group is attached to a tertiary carbon of an aliphatic alcohol condensation occurs; when attached to a primary aliphatic carbon no condensation occurs; when attached to a secondary aliphatic carbon probably no condensation occurs.



EXPERIMENTAL



Methyl Ethyl n-Butyl Carbinol

Methyl ethyl n-butyl carbinol was prepared by Whitmore's modification of the Grignard reaction (23). In a three-liter, three-necked, round-bottomed flask, fitted with an efficient stirrer, reflux condenser and dropping funnel, are placed first a few small crystals of iodine and then 98 grams(4 moles) of fresh, dry magnesium turnings. The bottom of the flask is warmed with a small flame until the iodine commences to vaporize, and is then allowed to cool while the n-butyl bromide is being weighed out. 30 c.c. of a mixture of 4 moles of the halide and 500 c.c. of dry diethyl ether is added directly to the dry magnesium. After the reaction has started and progressed for a few minutes, 200 c.c. of dry ether is added directly to the reaction mixture. 475 c.c. of the above ether-halide solution is placed in the dropping funnel and added with stirring, not faster than one drop per second. The remainder of the halide-ether solution is diluted with 300 c.c. of dry ether and added at the same rate with stirring. The mixture is allowed to reflux during the halide-ether addition, no external cooling being applied. It is not necessary to heat the mixture after the ether-halide solution has been added. Stirring is continued for four hours. Let stand over night.

To the n-butyl magnesium bromide is added a solution of four moles of pure, dry methyl ethyl ketone in an equal volume of anhydrous ether. The procedure is similar to that stated above for the preparation of the Grignard reagent.

The magnesium complex is decomposed in a four-liter beaker with ice and hydrochloric acid. The hydrolyzed product is extracted three times with ether. The ether extract is dried with a mixture of anhydrous potassium carbonate and calcium chloride. The alcohol is obtained by fractional distillation at reduced pressure after the ether has been boiled off on the steam bath. A small part of the octanol was redistilled at normal pressure, b.p.t. - 160° with no dehydration occurring.

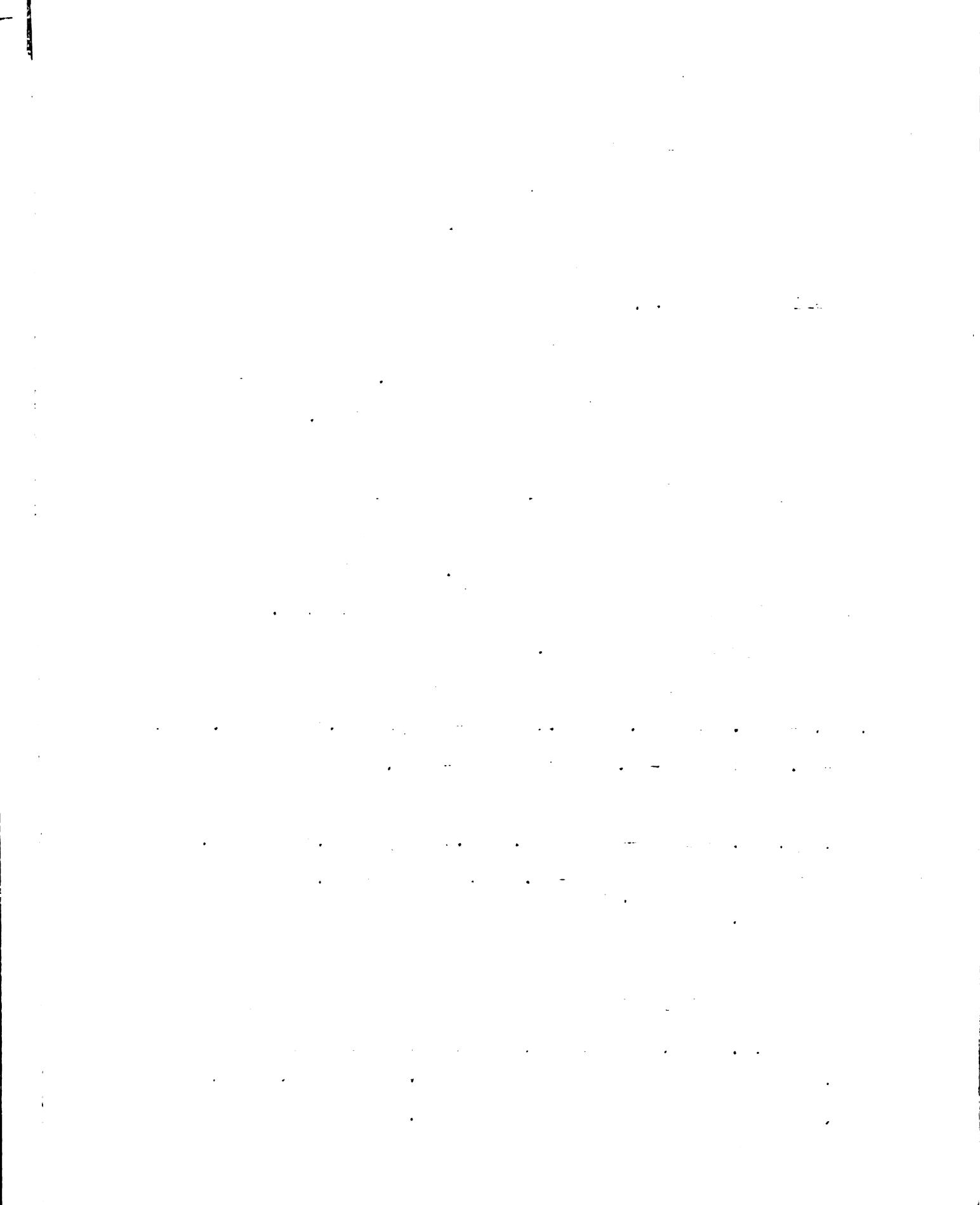
Rissegahn (24) gives the following constants:

B. Pt. - 163.5°, 158°/745 mm., 64° - 65°/16 mm.; D_4^0 - 0.8446,
 D_4^{15} - 0.8273; N_D^{19} - 1.42735; yield - 62%.

The constants for the alcohol prepared in this work: B. Pt. - 159° - 160°/745.5 mm., 65°/15 mm.; N_D^{22} - 1.4273 (Abbe refractometer); D_4^{22} - 0.82376; yield - 61.5% and 55% (two trials).

Table of Results

| | Solvent Ether c.c. | n-Butyl bromide gm. | Magnesium ketone mol. | Me et carbinol gm. | Me et n-bu gm. | % |
|----|--------------------------|---------------------------|-----------------------------|--------------------------|-------------------|-------|
| 1. | 1250 | 548 | 4 | 98 | 4 | 288.3 |
| | | | | | 4 | 317.5 |
| 2. | 1250 | 548 | 4 | 98 | 4 | 284 |
| | | | | | | 55% |



Methyl Ethyl tert-Butyl Carbinol

Tert-butyl chloride was prepared from tert-butyl alcohol and hydrochloric acid. The tertiary alkyl magnesium chlorides are more stable compounds, more suitable for reaction with the carbonyl group than the bromides or iodides (26).

Methyl ethyl t-butyl carbinol was prepared in a manner similar to methyl ethyl n-butyl carbinol (23). The reaction was difficult to carry out because of the solidification of the Grignard compound. Approximately one and one-half times as much ether was used as in the previous experiment. A few c.c. of ethyl bromide were used to start the reaction. Higher tertiary Grignard reagents are not suitable for syntheses which involve the addition of the Grignard reagent to the carbonyl group of a ketone or ester (26) (27). Hydrogen halide splits off from the tertiary alkyl halide resulting in olefin formation. The compound was fractionated under reduced pressure, boiling at 55°/12 mm. Dehydration occurred very easily so that the alcohol could not be distilled at normal pressure. It was not found possible to free the alcohol of considerable unsaturated impurities. The impure alcohol was very unsatisfactory for condensation with phenol. A tarry mass was the principal product of such condensations.

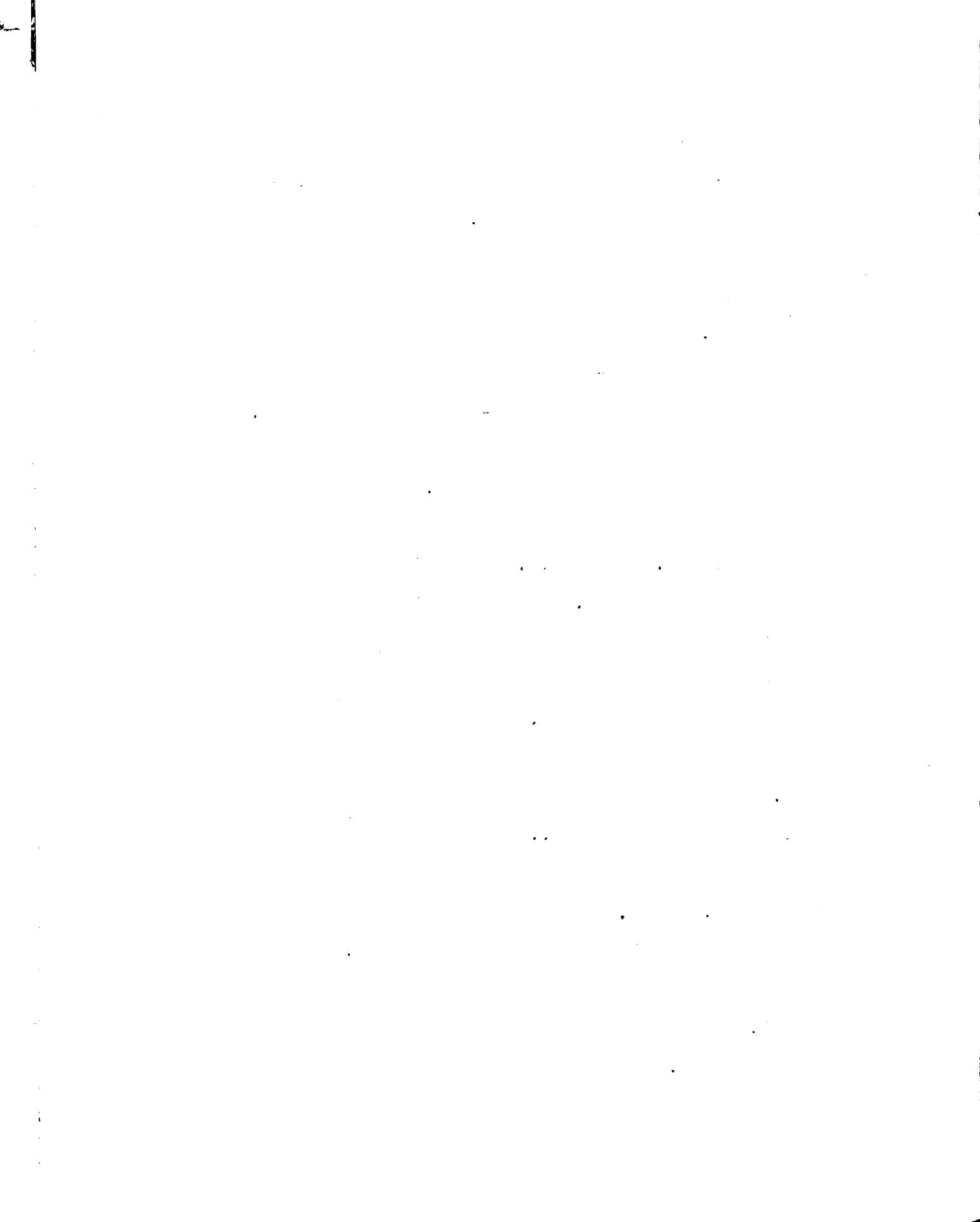


Table of Results

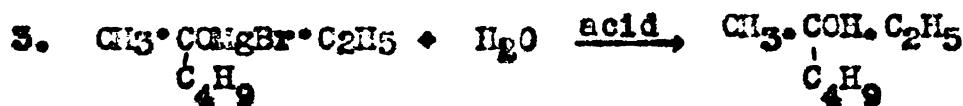
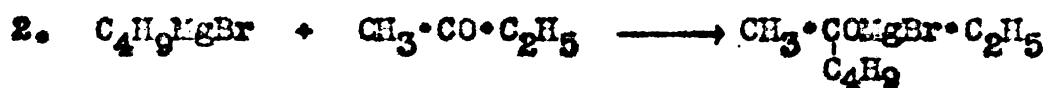
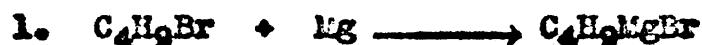
| | Solvent Ether c.c. | t-Butyl Chloride gm. | Magnesium mol. | Me et ketone gm. | Me et t-bu carbinol gm. | Me et t-bu carbinol mol. | Me et t-bu carbinol gm. | % | |
|----|--------------------------|----------------------------|-------------------|------------------------|----------------------------------|--------------------------------|-------------------------------|---|-------|
| 1. | 2000 | 370 | 4 | 98 | 4 | 288.3 | 4 | 5 | 10% |
| 2. | 2000 | 370 | 4 | 98 | 4 | 288.3 | 4 | 6 | 11.8% |

Methyl ethyl tert-butyl carbinol was also prepared by treating trimethyl acetyl chloride with equimolar quantities of methyl magnesium iodide and ethyl magnesium bromide. The following steps were involved: Pinacol hydrate (28) was dehydrated and rearranged to form pinacolone when boiled with concentrated H_2SO_4 (29). The pinacolone was converted to trimethyl acetic acid by treating with NaOH and Bra (30). PCl_3 was used to convert the acid to the acyl chloride (31). 50 gm. of trimethyl acetyl chloride were obtained. Equimolar quantities of ethyl magnesium bromide and methyl magnesium iodide were prepared by Whitmore's modification of the Grignard preparation (25). These were added dropwise to a solution of the acyl chloride in an equal volume of ether. The reaction mixture was stirred for four hours, let stand over night, hydrolyzed with ice and acid, extracted with ether, dried and fractionated. A yield of 14 gm. or 26% of the tertiary alcohol was obtained. This product showed no unsaturation and gave a good condensation with phenol.

This octanol was also prepared by treating pinacolone with an equimolar quantity of ethyl magnesium bromide (32). Pinacol hydrate was prepared as in the previous manner (28). Pinacolone was prepared from the pinacol hydrate (29). EtMgBr was prepared and added as previously (23). 65 gm. of the octanol was obtained. This was a 63.3% yield. A condenser tube is inserted in the vacuum distillation apparatus since the alcohol must be distilled at low temperature to avoid dehydration.
 B. Pt. - $34^\circ/2$ mm., $149^\circ/745$ mm.

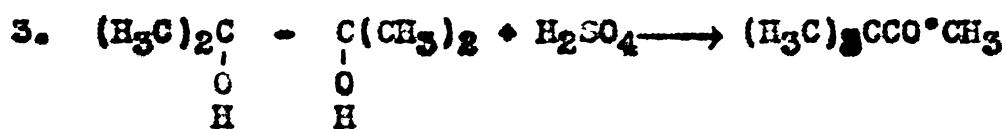
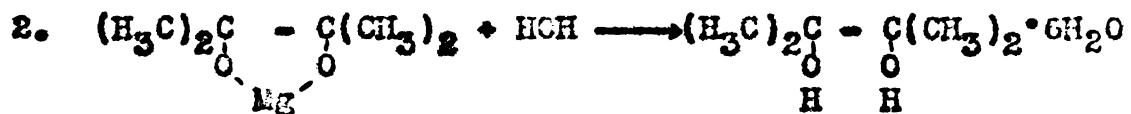
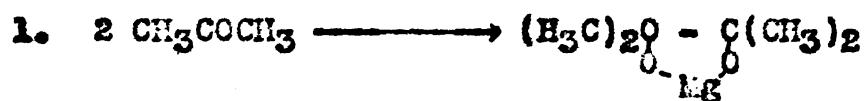
Equations for the Three Methods Used

I.

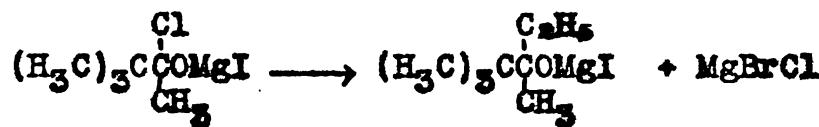


Yield = 10%

II.



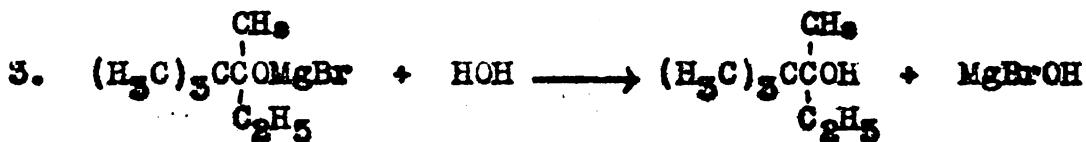
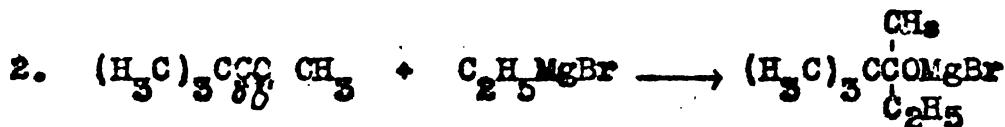
II.



Yield - 26%

III.

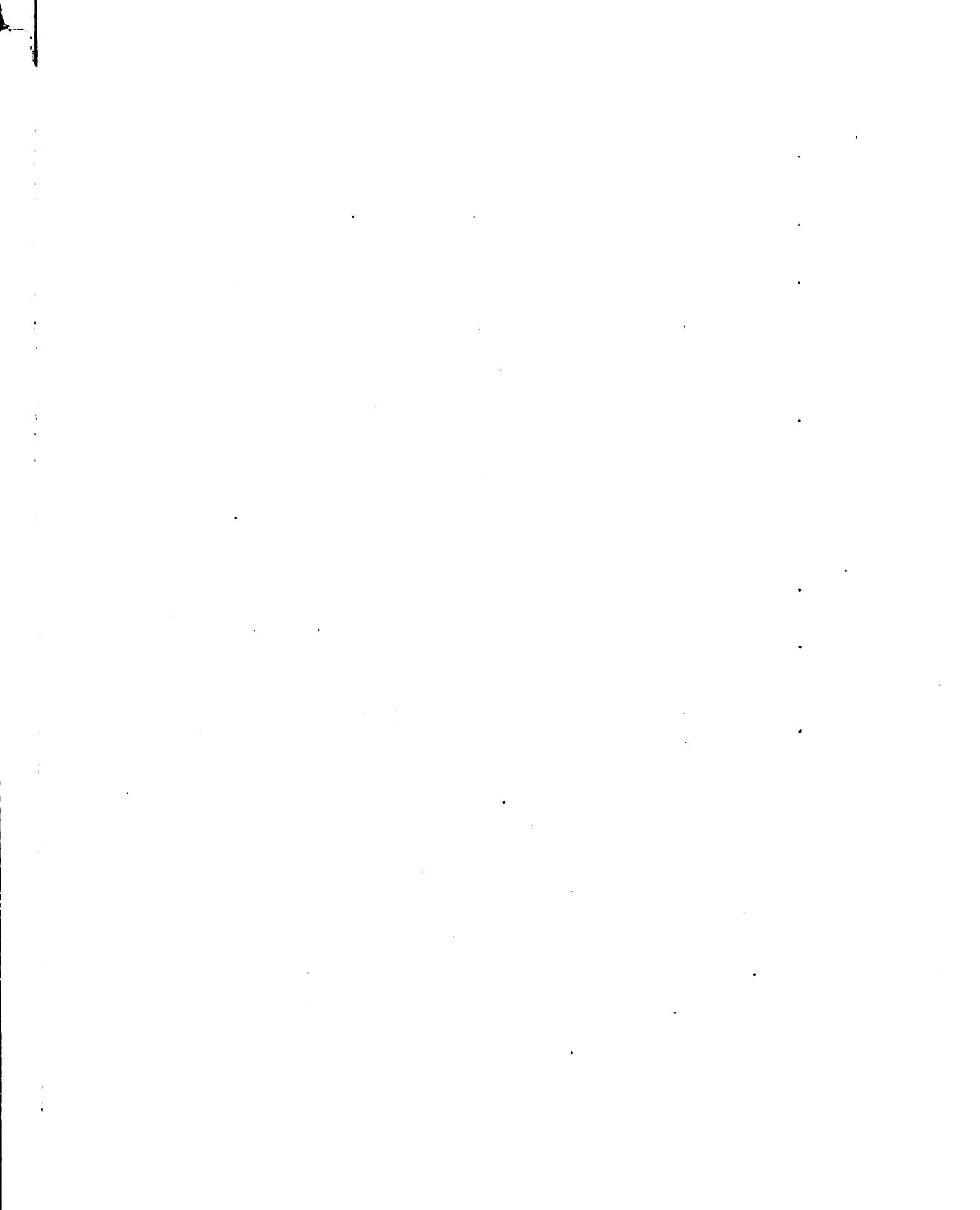
1. Preparation of pinacolone same as in II



Yield - 63.3%

Condensations

The two alcohols prepared were condensed with phenol. The Huston method of condensation with AlCl_3 was used (2). Both the method and the quantities of the reagents were varied.



Five condensations of phenol with methyl ethyl n-butyl carbinol were run. In two of the condensations 1/4 mole of the alcohol and 1/4 mole of phenol were suspended in 80 c.c. of petroleum ether. 1/8 mole of anhydrous AlCl_3 was added in small quantities. Previous work in this laboratory gives the method in detail (9), (10). In two of the condensations the technique was varied somewhat. 1/8 mole of AlCl_3 was suspended in 50 c.c. of petroleum ether. 1/4 mole of the alcohol and 1/4 mole of the phenol, dissolved in 50 c.c. of petroleum ether, were added dropwise. The temperature must be kept below 30°. Any appreciable rise in temperature results in the formation of a sticky mass in the bottom of the flask, with the resultant poor condensations. Yields were not appreciably affected by the technique. In a final run 5/4 mole of phenol was used, with the other quantities remaining the same. The yield was reduced.

Table of Results

| Solvent Pet. Ether c.c. | Phenol gm. | Me et n-bu carbinol mol. | AlCl_3 gm. | Me et n-bu p-CH ₃ ph methane gm. | % yield |
|-------------------------------|---------------|--------------------------------|------------------------|---|----------|
| 1. | 80 | 22.8 1/4 | 32.5 1/4 | 17.5 1/8 | 12 23.4% |
| 2. | 80 | 22.8 1/4 | 32.5 1/4 | 17.5 1/8 | 14 27.2% |
| 3. | 80 | 114.0 5/4 | 32.5 1/4 | 17.5 1/8 | 9 17.3% |
| 4. | 100 | 22.8 1/4 | 32.5 1/4 | 17.5 1/8 | 11 21.5% |
| 5. | 100 | 22.8 1/4 | 32.5 1/4 | 17.5 1/8 | 15 29.1% |

The methyl ethyl n-butyl p-hydroxy phenyl methane distilled at 145° - 147°/7 mm. The compound would not crystallize. It was analyzed and derivatives were prepared.

Analysis

| | | |
|------------|-----------------|-------------------|
| Calculated | Carbon — 81.49% | Hydrogen — 10.75% |
| Found | Carbon — 81.75% | Hydrogen — 10.84% |

Four condensations of phenol and methyl ethyl tert-butyl carbinol in the presence of AlCl_3 were made. The procedures used previously were again followed. There were no appreciable differences in yields.

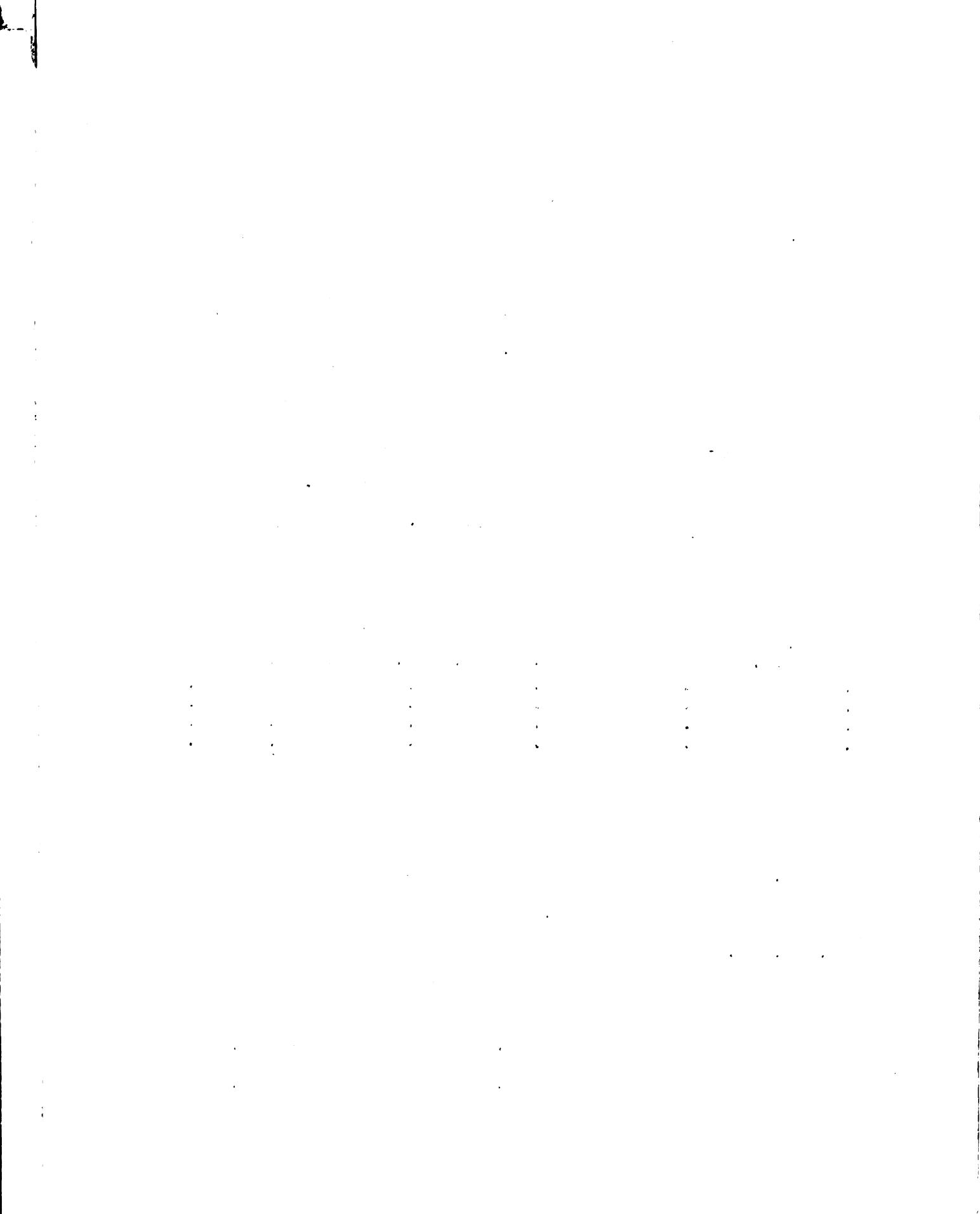
Table of Results

| Solvent Pet. Ether | Phenol g.m. | Me et t-bu Carbinol mol. | AlCl_3 g.m. | Me et t-bu p-OH ph methane g.m. | % yield |
|-----------------------|----------------|--------------------------------|-------------------------|---------------------------------------|----------------|
| 1. 80 | 11.4 | 1/8 | 16.25 | 1/8 8.75 | 1/16 3 11.9% |
| 2. 80 | 11.4 | 1/8 | 16.25 | 1/8 8.75 | 1/16 6 25.4% |
| 3. 100 | 11.4 | 1/8 | 16.25 | 1/8 8.75 | 1/16 5.1 19.7% |
| 4. 100 | 22.8 | 1/4 | 32.50 | 1/4 17.50 | 1/8 11.8 22.7% |

The alcohol used in the first run was partly unsaturated. The methyl ethyl tert-butyl p-hydroxy phenyl methane solidified on cooling. It was dried on a porous plate. M. Pt. — 57° to 58°

Analysis

| | | |
|------------|-----------------|-------------------|
| Calculated | Carbon — 81.49% | Hydrogen — 10.75% |
| Found | Carbon — 81.32% | Hydrogen — 10.82% |



Preparation of Derivatives

Esters

Benzoyl and acetyl esters were prepared by a modification of the pyridine method (33). A typical run is as follows: One and a half c.c. of benzoyl chloride is added to a mixture of 1.6 grams of tert-octyl phenol dissolved in 2 c.c. of pyridine in a 250 c.c. flask carrying a reflux condenser. The flask is warmed with a free flame until the mixture boils gently. After heating for about one hour in the hood the flask is cooled and then filled with water. The solid is suction filtered and washed thoroughly with water until there is no odor of pyridine. The solid is purified by recrystallization from alcohol.

When the ester formed was a liquid about four times as large quantities were used. The product was treated with water and then extracted with ether. The ether extract was washed thoroughly with dilute hydrochloric acid to remove any pyridine. The ether was removed, and the ester was distilled under reduced pressure. If the distilled ester solidified when cooled, it was dried between filter paper and recrystallized from fifty per cent alcohol.



Urethans

The alpha naphthyl urethans were prepared (34). About 1 c.c. of α -naphthyl isocyanate was added to 1 c.c. of the tert-octyl phenol in a 50 c.c. Erlenmeyer flask. A few crystals of anhydrous potassium carbonate were added. A stopper containing a calcium chloride drying tube was inserted. The flask was warmed gently for ten minutes on a steam bath. After cooling, the solid, impure urethan was dissolved in ligroin, filtered through a warm suction filter and crystallized. The crystals were again suction filtered and then recrystallized from alcohol. No water must enter the flask, during the reaction since dina-phthyl urea might be formed. The α -naphthylurethan of methyl ethyl tert-butyl p-hydroxy phenyl methane was much more difficult to crystallize than was the derivative of methyl ethyl n-butyl p-OH phenyl methane.

Analysis

The acetyl and benzoyl esters were analyzed for carbon and hydrogen by Fisher's modification of the Liebig combustion method (35). The results are given in tabular form.

The α -naphthylurethans were analyzed for nitrogen content. Allen's micro Kjeldahl apparatus and modification of the Pregel method were used (36) (37). The results are listed in tabular form.

Acetyl and Benzoyl Esters

| Ocetyl Phenol | Ester | Analysis | | | |
|----------------------------------|---------|-----------------------|----------------|----------------------|--------------------|
| 1. Me et n-bu p-OH ph methane | Acetyl | B.Pt. - 146°/5 mm. | Calc. Found | C-77.36% C-77.04% | H-9.71% H-9.59% |
| 2. Me et n-bu p-OH ph methane | Benzoyl | B.Pt. - 194°/2 mm. | Calc. Found | C-81.24% C-81.03% | H-8.45% H-8.44% |
| 3. Me et t-bu p-OH ph methane | Benzoyl | M.Pt. - 109° | Calc. Found | C-81.24% C-81.47% | H-8.45% H-8.40% |

Alpha Naphthyl Urethans

| Ocetyl Phenol | M. Pt. | Analysis | | | |
|----------------------------------|--------|----------------|--------|----------------|--|
| 1. Me et n-bu p-OH ph methane | 91° | Calc. Found | N N | 3.77% 3.78% | |
| 2. Me et n-bu p-OH ph methane | 91° | Calc. Found | N N | 3.77% 3.84% | |
| (Proof of structure product) | | | | | |
| 3. Me et t-bu p-OH ph methane | 114° | Calc. Found | N N | 3.77% 3.85% | |

Proof of structure

The structure of methyl ethyl n-butyl p-hydroxy phenyl methane was proved by preparing the octyl benzene, nitrating, reducing to the amino compound, diazotizing and hydrolyzing to the phenol. The position of the octyl group was proved by Carius oxidation of the nitro octylbenzene to p-nitrobenzoic acid. The α -naphthylurethan of the phenol was prepared.

Analysis, melting point and mixed melting point determinations proved it to be the same as the α -naphthylurethan of the original condensed phenol.

1. Preparation of the octyl benzene

The octyl benzene was prepared by the Huston aluminum chloride condensation method (2). Three 1/4 mole runs were made and 55 g. of the product obtained.

2. Preparation of octyl nitrobenzene

The nitration of the octyl benzene was carried out by an adaptation of Halherbe's procedure (38). An equal weight of the hydrocarbon was added slowly to fuming nitric acid (sp. gr. - 1.51) in a 250 c.c. flask. After the first violent reaction is complete the mixture was shaken vigorously and allowed to remain in a water bath at 90° for one hour, being shaken from time to time. Water was poured into the flask, the product separated, washed with sodium carbonate solution, dried with anhydrous calcium chloride and distilled under reduced pressure.

3. Reduction of p-nitro tert-octyl benzene

Reduction was carried out by means of tin and concentrated hydrochloric acid. A typical run is as follows (39): 30 gm. of tin are put into a 500 c.c. round-bottom flask fitted with an air condenser. 100 c.c. of concentrated HCl is added and then 20 gm. of p-nitro tert-octyl benzene.



The mixture is warmed gently under the hood. After two hours the mixture is allowed to cool. The nitro compound floating on the surface changed into a crystalline mass. This was treated with a large amount of water and made alkaline with NaOH, and finally steam distilled from a 2-liter flask. The amino compound coming over with the steam is salted out, separated, dried with crushed, solid KOH and distilled under reduced pressure.

4. Oxidation of p-nitro tert-octyl benzene

The oxidation method was adopted from Malherbe (38). One and a half grams of the octyl nitro compound and 20 c.c. of dilute nitric acid (1.20 or 6N) were sealed in a Carius tube and heated at 150° in the Carius combustion furnace. After ten hours yellow-white crystals appeared in the tube. The tube was allowed to cool and opened. The contents were poured into 400 c.c. of water and the crystals suction filtered. The crystals were freed from some unchanged nitro compound by washing with a little cooled ether. The crystals thus obtained melted at 238°-239°. A mixed melting point determination with p-nitrobenzoic acid showed no depression.

5. Phenol from p-amino tert-octyl benzene

A typical diazotization is as follows (40): 4 1/2 gm. of p-amino tert-octyl benzene are treated with 2.5 c.c. of concentrated H₂SO₄ in 15 c.c. of water. The



solid salt formed is suspended in 300 c.c. of water. After cooling in an ice bath to 5°, 1.9 gm. of sodium nitrite in 8 c.c. of water is added drop by drop to the stirred suspension from a dropping funnel with a capillary tube attached to the stem. Starch iodide paper is used to determine when sufficient sodium nitrite has been added. The diazotization mixture must be acid throughout the reaction.

The diazotized solution is now warmed on the steam bath and subjected to steam distillation. *p*-tert-Octyl phenol was obtained as a liquid. The *a*-naphthylurethan was prepared. It gave the same melting point as the urethan of the original condensed phenol. A mixed melting point determination showed no depression.

THEORETICAL AND SUMMARY

The reaction between the Grignard reagent and the carbonyl group of a ketone to produce a tertiary octanol worked successfully in the preparation of methyl ethyl n-butyl carbinol. The use of this same method to prepare methyl ethyl tert-butyl carbinol was not satisfactory and confirms the work of Whitmore in this field. The preparation of this octanol by the reaction of trimethyl acetyl chloride with methyl and ethyl magnesium halides was not satisfactory, being time consuming and resulting in a poor yield. The octanol was successfully prepared by the reaction of pinacolone and ethyl magnesium bromide, confirming the work of Clarke and Jones.

Methyl ethyl n-butyl carbinol is much stabler than is methyl ethyl t-butyl carbinol. The former was not dehydrated appreciably when distilled at 159°/750 mm. The latter dehydrated when distilled at 106°/200 mm.

Methyl ethyl n-butyl carbinol and methyl ethyl t-butyl carbinol condensed effectively with phenol in the presence of aluminum chloride to yield p-alkyl phenols. The method of adding the reagents did not effect the results appreciably.

Methyl ethyl n-butyl carbinol condensed with benzene to yield octyl benzene.

Alpha naphthylurethans are more satisfactory derivatives for the t-octyl phenols than are the acetyl



and benzoyl esters.

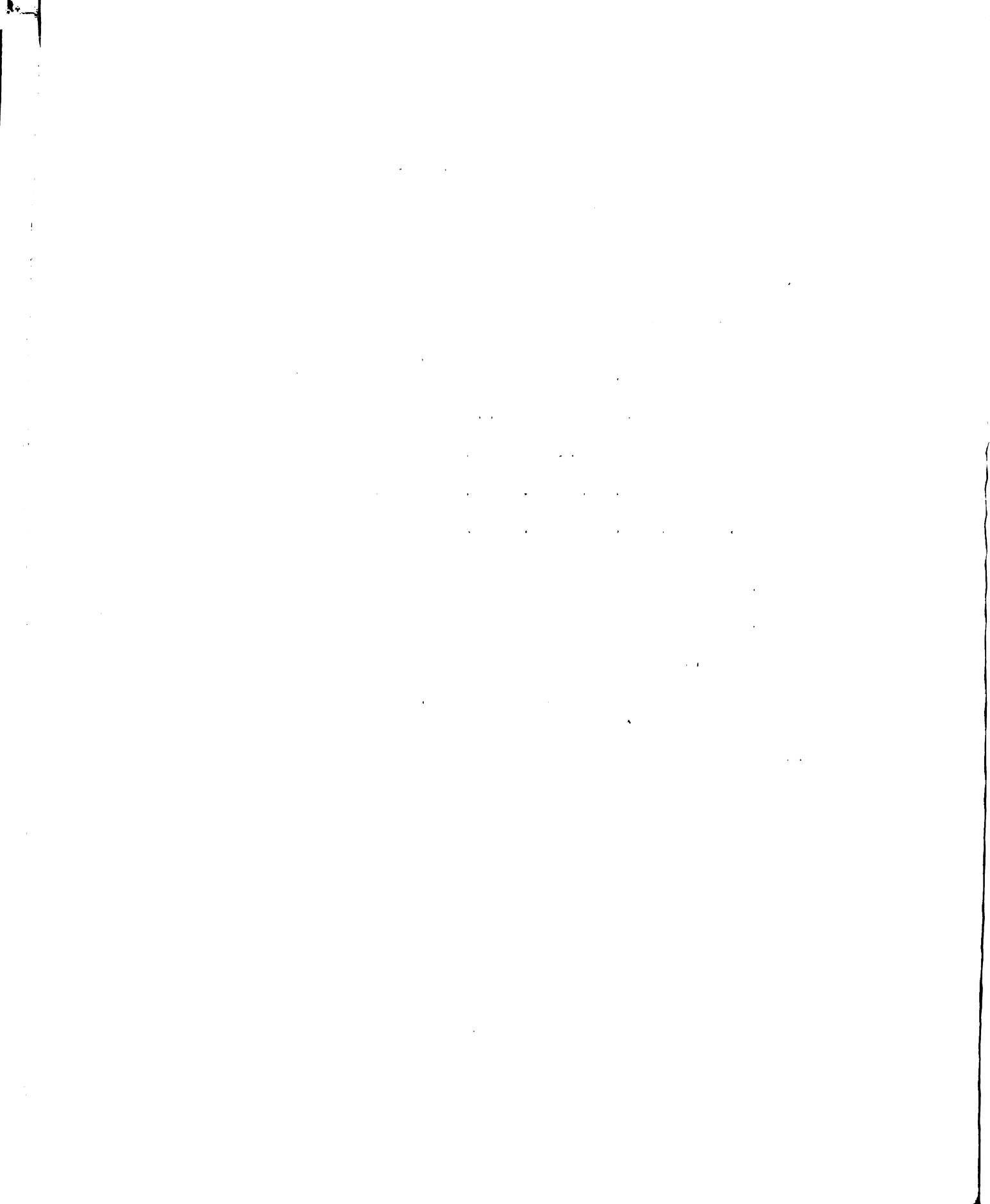
The octyl group takes the position para to the hydroxyl of the phenol as shown by the oxidation of the octyl nitrobenzene to para nitrobenzoic acid.

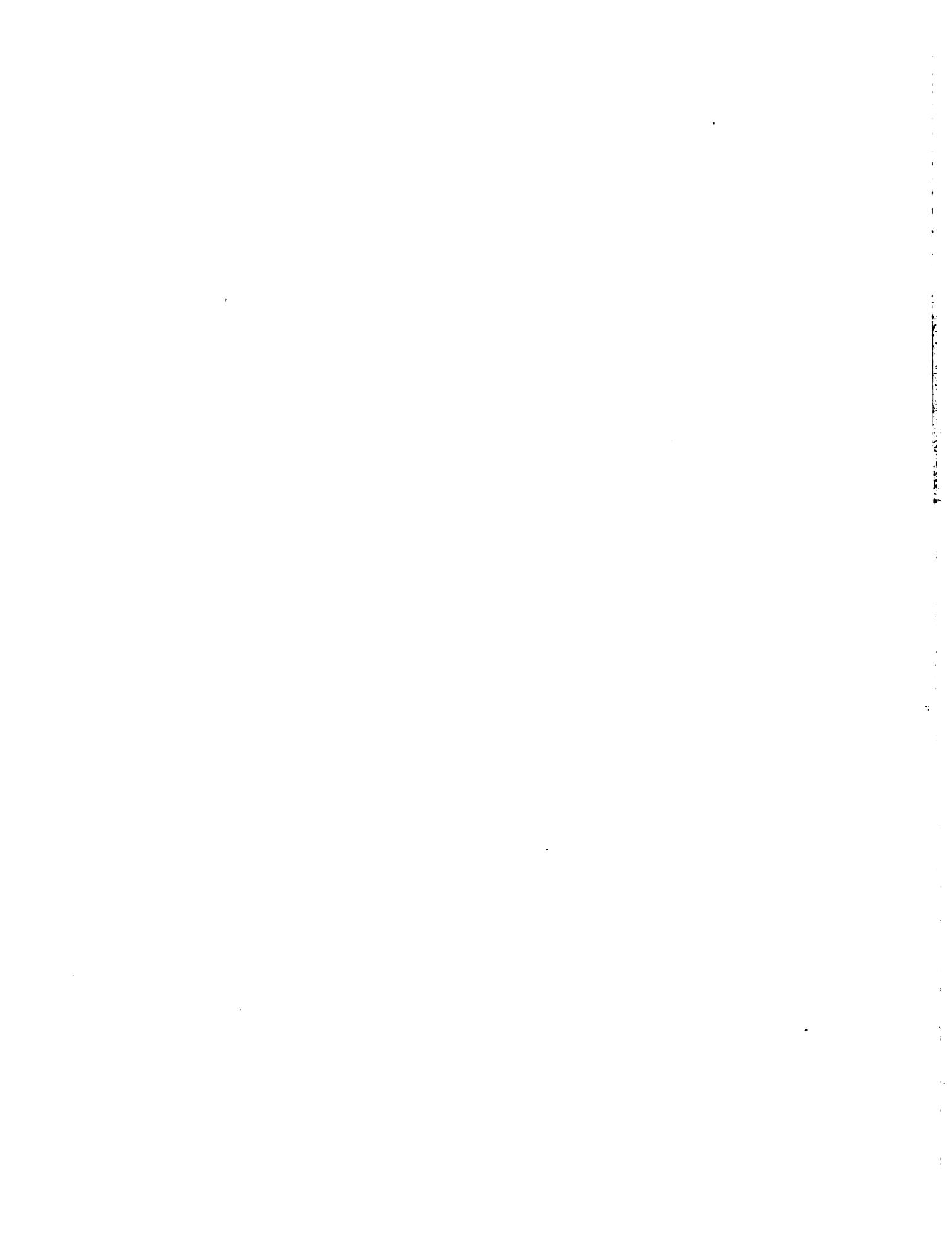
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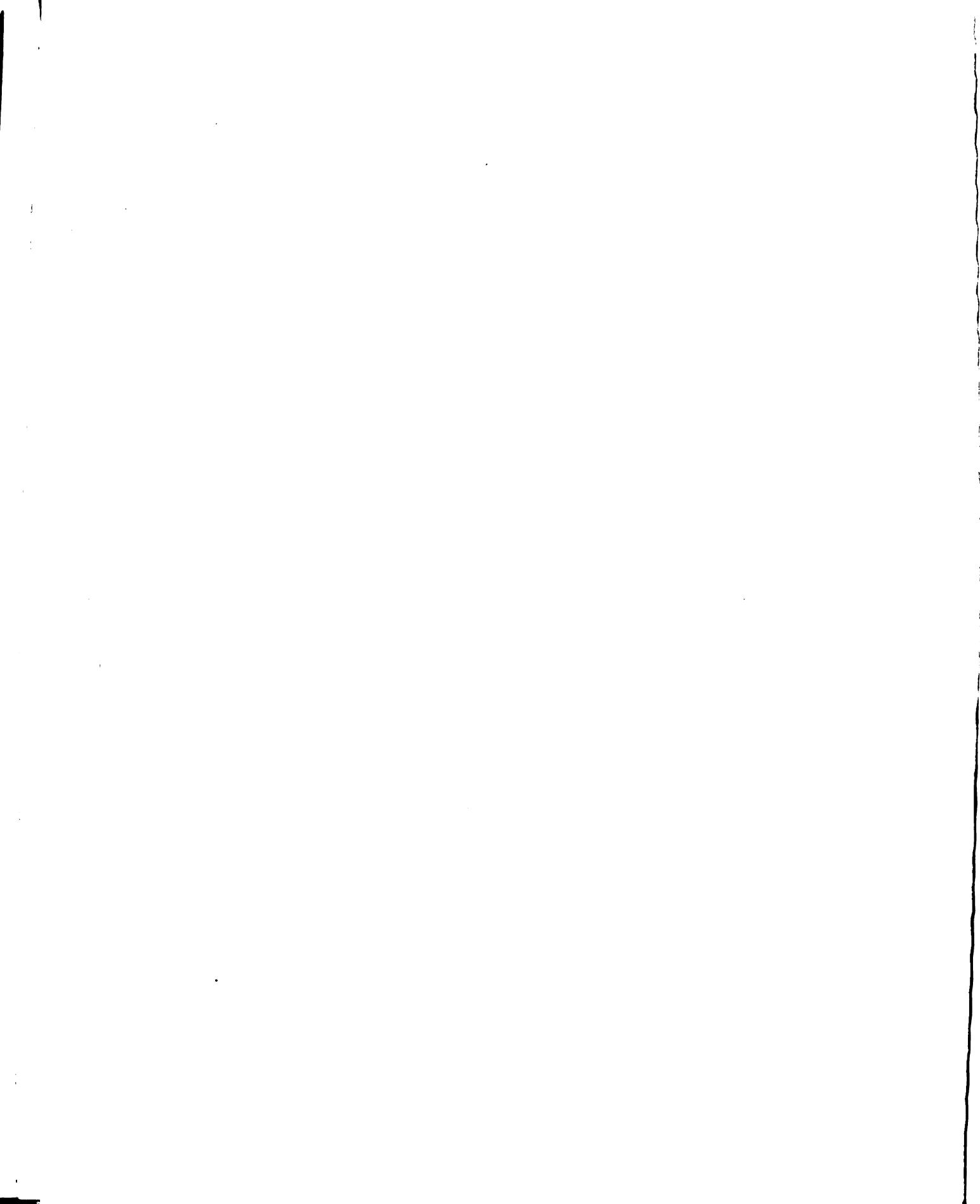
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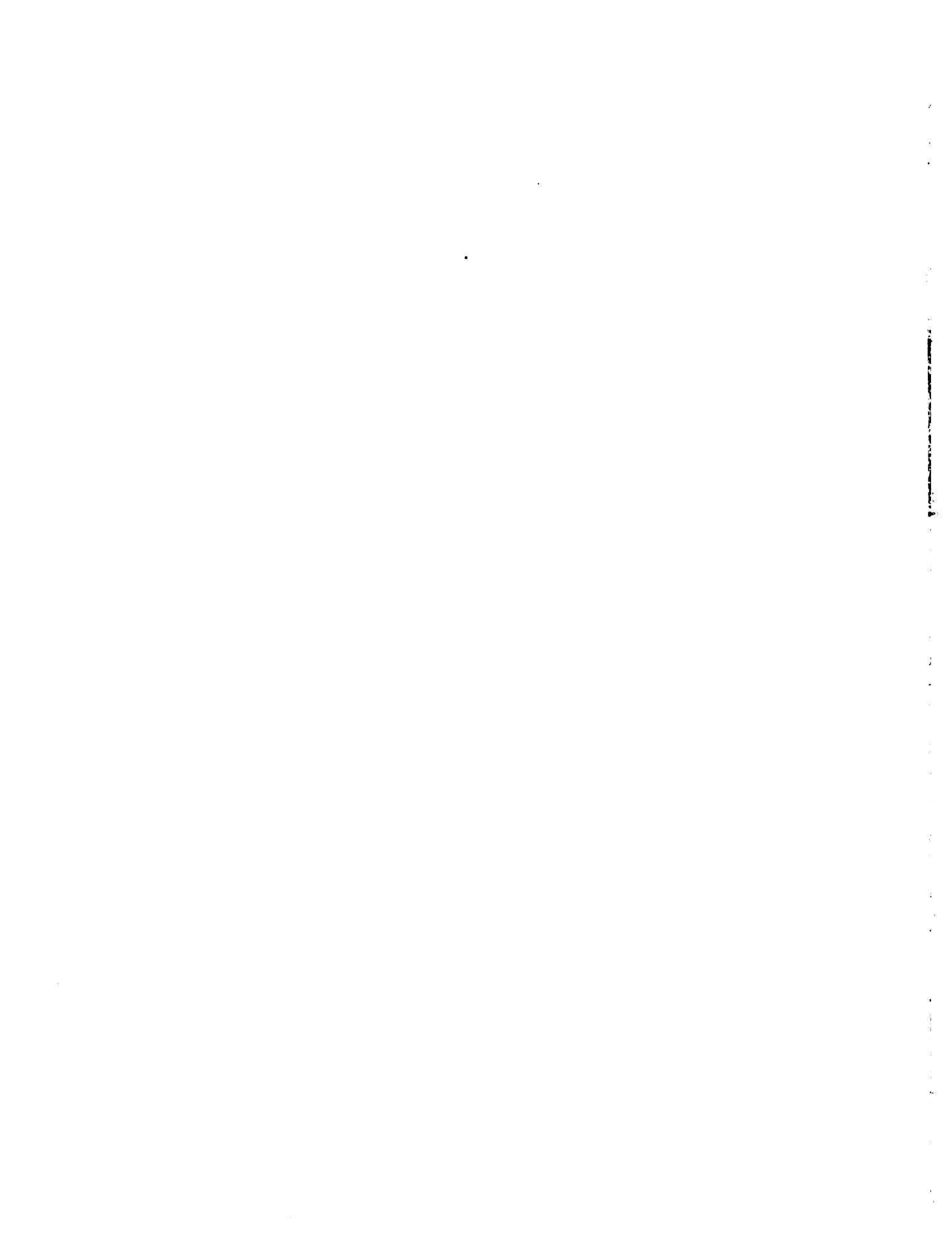
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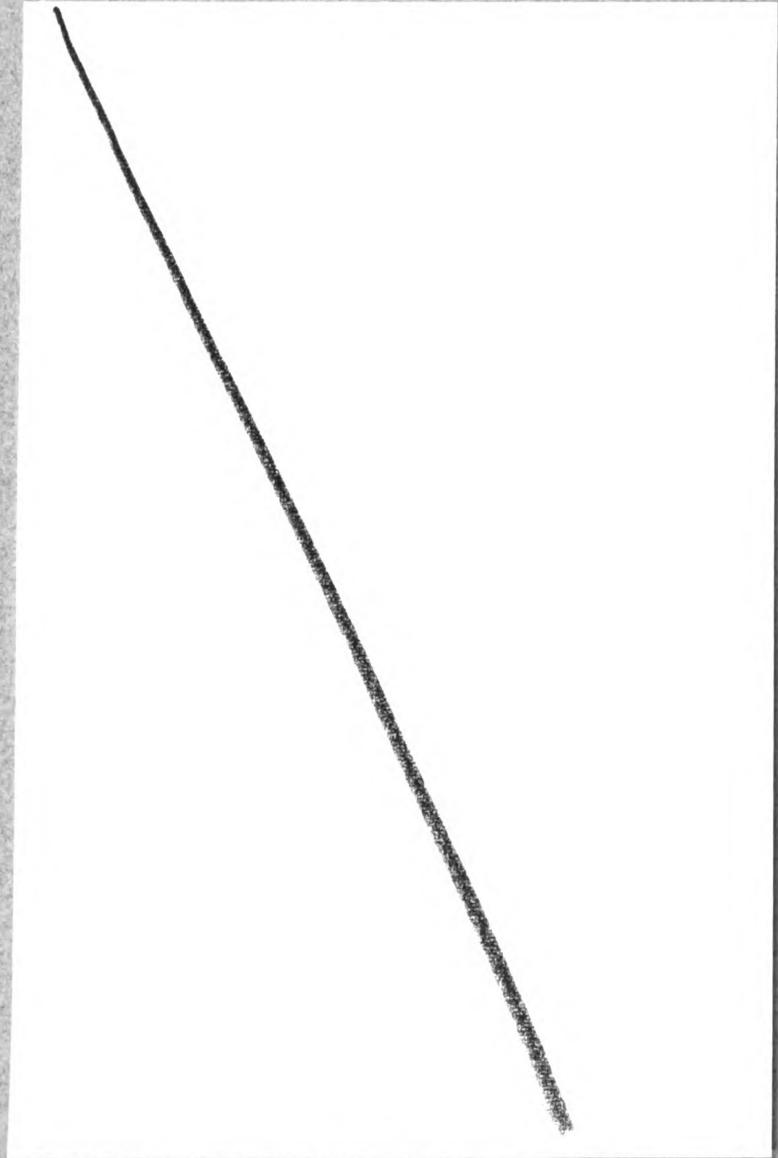
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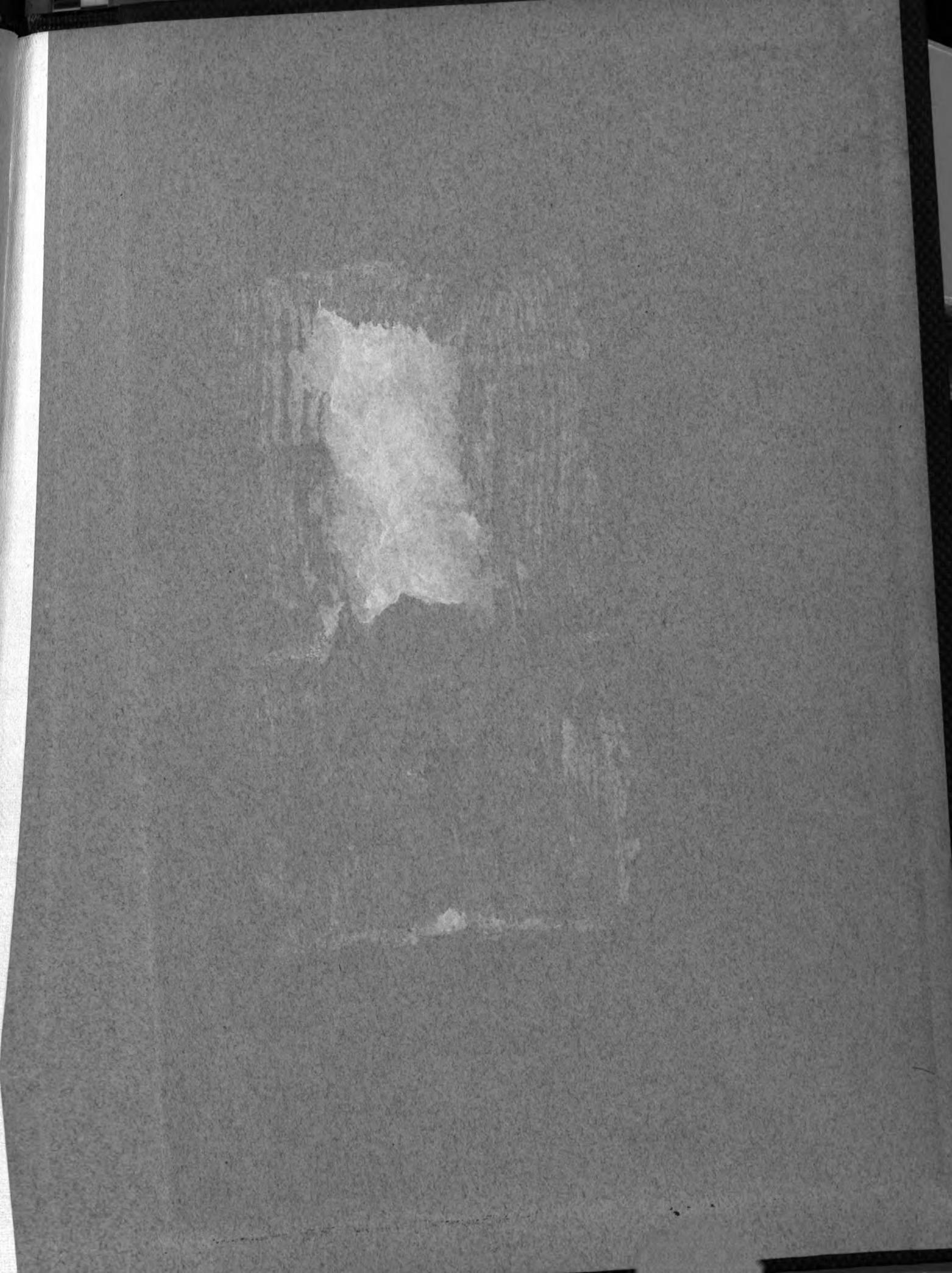












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