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13 February 1970

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Technical Note No. 10  
on the  
Development of Technologies in  
Petroleum Refining

(London, 23rd October 1969)

PET.SHP. B/4

TECHNICAL NOTE NO. 10  
ON THE DEVELOPMENT

OF PETROCHEMICALS

by

N. Praschik  
United Hungarian Chemical Works  
Budapest  
Hungary

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Petrochemistry is today characterised by the steep increase of the unit capacity of the producing plants. The second characteristic feature is the considerable variation of the by-products. Since these two factors affect all the other production costs, we may draw the conclusion that the construction of a petrochemical plant is a technical and very expensive large capital investment. It is necessary of course to have sufficient markets for selling products produced at these capacities. The demand on the market depends upon

- the degree of industrial development of the country,
- the use of materials by industry and agriculture,
- the population of the country.

Since the developing countries in some cases have not sufficient capital at their disposal, neither do the market needs justify the construction of big capacities, it becomes increasingly difficult to start a reasonably sized and viable petrochemical industry. It is therefore necessary - when making plans for the development of the petrochemical industry - to consider the possibilities of cooperation between the various production facilities planned in the country and to further and explore cooperation between plants situated in neighbouring countries.

The aim of this lecture is to outline some mathematical models, suitable for assessing the economic effect of petrochemical cooperation.

From the technical + economical point of view - cooperation may be realised at various levels. If each of the companies A, B and C / which may be situated in the same country or in neighbouring countries/ are considering the construction of a petrochemical complex having a specified assortment of products, then the cooperation may be effected on three levels.

- 1/ The cooperation affects the production of olefins, thus allowing a big capacity naphtha cracker to be constructed. The olefins are transported to the companies A, B and C, but the assortment of products remains unchanged.
- 2/ The cooperation affects the assortment of products too, with the aim that each product should be produced only on one site, thus ensuring the construction of bigger - capacity units.



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23 July 1969

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United Nations Industrial Development Organization

International Petrochemical Symposium on the  
Development of the Petrochemical Industries in  
Developing Countries

PET. SYM. 3/4

Baku, USSR, 20 - 31 October 1969

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SUMMARY

MATHEMATICAL MODELLING  
OF THE DEVELOPMENT OF PETROCHEMISTRY 1/

by

M. Proisich

United Hungarian Chemical Works  
Budapest, Hungary

Petrochemistry in the industrially developed countries is characterised by the steep increase of the unit capacity of the producing equipment. This is due partly to the marked growth of the needs in petrochemical products, partly to the aim at lowering the production costs.

The developing countries on the other hand generally do not have either sufficient market needs, nor in some cases enough capital to construct such petrochemical complexes, which approach the capacities nowadays built and which therefore prove to be competitive in the perspective. When formulating the development conception of a petrochemical industry giving favourable economic results it is advisable to

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about the possibilities of cooperation between the various production facilities planned in the country and to assess their economic effect. This survey may be extended in some cases to cooperation between plants built in other neighboring countries.

The lecture introduces the models, suitable to solve tasks of this type.

The firm will answer the following question. Which is the economically ~~best~~ solution,

- to construct simultaneously on different sites naphtha cracker having relatively small capacities, or
- to construct a single big-capacity one-stage naphtha cracker and to supply the refineries to the consumers by pipeline or by other means.

The model provides information about the optimum size of the central naphtha cracker.

The second model selects the optimal combination of petrochemical activities leading to achieve the optimum rate of return of the investment. For this purpose the market needs have to be revealed. The available investment sum determines - as the upper limit - the solution of the task. The model is based on linear programming.

The third model investigates the specialization of the production inside the country or between manufacturing countries, with the purpose of obtaining big-capacity plants and to lower hence the production costs. The economic optimum is reached, when the sum of the production costs of the plants figuring simultaneously in the model, attains minimum value. The model is based on integer programming.

The examples discussed in the lecture support the importance of adopting mathematical methods for the elaboration of conceptions for the development of the industry.

the first two digits of the identification number. The first digit is the year of birth and the second digit is the month of birth. The last four digits are the individual's identification number.

### DATA

The data consists of 1000 individuals. Each individual has a unique identification number. The data is organized into three main sections: individual information, household information, and economic information. Individual information includes age, gender, race, ethnicity, education level, and employment status. Household information includes family size, income, and居住地 (residence). Economic information includes occupation, industry, and production costs.

Individual information is used to calculate individual production costs. Household information is used to calculate household production costs. Economic information is used to calculate economic production costs. These three types of production costs are then summed to get the total production cost for each individual.

The data is also used to calculate individual production costs for each individual. This is done by summing the production costs for each individual. The individual production costs are then divided by the total production costs for each individual. This results in the individual production cost for each individual. The individual production cost for each individual is then multiplied by the individual's production cost for each individual. This results in the individual production cost for each individual.

The individual production cost for each individual is then divided by the total production cost for each individual. This results in the individual production cost for each individual.

The individual production cost for each individual is then divided by the total production cost for each individual.

$$T = d_1 \cdot s_1 \quad \text{where}$$

$$d_1 = 1,1 \cdot \sqrt{(x-x_1)^2 + (y-y_1)^2} \quad \text{the multiplier 1,1}$$

takes into account the deviation of pipelines, roads etc. from the straight connection, it can be changed according to local conditions.

The total transport cost is computed by a subroutine for each of the measured pipelines and for tank-car transport (propylene).

The sum of transport costs is expressed by the following equation:

$$T = \sum_{i=1}^{i+j+p} s_i \cdot d_i$$

where  $i$  = number of raphine producers,

$j$  = number of ethylene consumers,

$p$  = number of propylene consumers.

To find the minimum value of the function  $T$ , i.e. to find the lowest point of the parabolic surface it is necessary to differentiate partially with respect to  $x$  and  $y$  and to seek those values of  $x$  and  $y$ , where the differential is equal to zero.

$$\frac{\partial T}{\partial x} = \sum_{e=1}^{i+j+p} s_e \frac{\partial d_e}{\partial x} = \sum_{e=1}^{i+j+p} \frac{s_e(x - x_e)}{d_e} = 0$$

$$\frac{\partial T}{\partial y} = \sum_{e=1}^{i+j+p} s_e \frac{\partial d_e}{\partial y} = \sum_{e=1}^{i+j+p} \frac{s_e(y - y_e)}{d_e} = 0$$

*Journal of the American Statistical Association*, Vol. 33, No. 191, March, 1938.

## TABLE 1 - continued

Investment costs	-	2,55
Production costs	-	6,0

Secondly, we can assume, in the example presented about 1% of the investment costs can be saved if the production costs may be saved.

Thirdly, we can assume that the values of utilities on site I are equal to those on site II, which assumption may not be correct, since the site II defined by the optimal coordinates may be unsuitable for the location of industry. To prove our statement we studied the deviation from the optimal coordinates in the total area of the plant. We moved the plant X on a circle /radius = 3 km/ and determined the total production cost on four sites. The values are given in Table 2, column 1. Thereupon we concluded, that the system of companies can produce their product on an area of  $\sim 3000 \text{ km}^2$  a suitable place for the plant.

The important question is, how this type of cooperation cannot be determined. In order to do this we can indicate, that the crucial consumer is the largest among the consumers. His distance relative to the smaller consumers is minimal. Finally, let us of which co-operative activities may take place.

Case 2

If we assume that there is a market for the total quantity of the products figuring in the plan of the companies A, B and C, then further savings in investment costs and production costs are possible by specializing the production. Specialization is only possible if the envisaged production programs of the enterprises concerned cooperation contain identical products.

To introduce a first simplified model which may be used in such circumstances, let us start from the following suppositions:

- the companies A and B are considering the specialization of their production;
- both companies have planned the production of two ethylene - derivatives  $E_1$  and  $E_2$  and two propylene - derivatives  $P_1$  and  $P_2$ ,





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	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	541	542	543	544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560	561	562	563	564	565	566	567	568	569	570	571	572	573	574	575	576	577	578	579	580	581	582	583	584	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600	601	602	603	604	605	606	607	608	609	610	611	612	613	614	615	616	617	618	619	620	621	622	623	624	625	626	627	628	629	630	631	632	633	634	635	636	637	638	639	640	641	642	643	644	645	646	647	648	649	650	651	652	653	654	655	656	657	658	659	660	661	662	663	664	665	666	667	668	669	670	671	672	673	674	675	676	677	678	679	680	681	682	683	684	685	686	687	688	689	690	691	692	693	694	695	696	697	698	699	700	701	702	703	704	705	706	707	708	709	710	711	712	713	714	715	716	717	718	719	720	721	722	723	724	725	726	727	728	729	730	731	732	733	734	735	736	737	738	739	740	741	742	743	744	745	746	747	748	749	750	751	752	753	754	755	756	757	758	759	760	761	762	763	764	765	766	767	768	769	770	771	772	773	774	775	776	777	778	779	780	781	782	783	784	785	786	787	788	789	790	791	792	793	794	795	796	797	798	799	800	801	802	803	804	805	806	807	808	809	8010	8011	8012	8013	8014	8015	8016	8017	8018	8019	8020	8021	8022	8023	8024	8025	8026	8027	8028	8029	8030	8031	8032	8033	8034	8035	8036	8037	8038	8039	8040	8041	8042	8043	8044	8045	8046	8047	8048	8049	8050	8051	8052	8053	8054	8055	8056	8057	8058	8059	8060	8061	8062	8063	8064	8065	8066	8067	8068	8069	8070	8071	8072	8073	8074	8075	8076	8077	8078	8079	8080	8081	8082	8083	8084	8085	8086	8087	8088	8089	80810	80811	80812	80813	80814	80815	80816	80817	80818	80819	80820	80821	80822	80823	80824	80825	80826	80827	80828	80829	80830	80831	80832	80833	80834	80835	80836	80837	80838	80839	80840	80841	80842	80843	80844	80845	80846	80847	80848	80849	80850	80851	80852	80853	80854	80855	80856	80857	80858	80859	80860	80861	80862	80863	80864	80865	80866	80867	80868	80869	80870	80871	80872	80873	80874	80875	80876	80877	80878	80879	80880	80881	80882	80883	80884	80885	80886	80887	80888	80889	80890	80891	80892	80893	80894	80895	80896	80897	80898	80899	80900	80901	80902	80903	80904	80905	80906	80907	80908	80909	80910	80911	80912	80913	80914	80915	80916	80917	80918	80919	80920	80921	80922	80923	80924	80925	80926	80927	80928	80929	80930	80931	80932	80933	80934	80935	80936	80937	80938	80939	80940	80941	80942	80943	80944	80945	80946	80947	80948	80949	80950	80951	80952	80953	80954	80955	80956	80957	80958	80959	80960	80961	80962	80963	80964	80965	80966	80967	80968	80969	80970	80971	80972	80973	80974	80975	80976	80977	80978	80979	80980	80981	80982	80983	80984	80985	80986	80987	80988	80989	80990	80991	80992	80993	80994	80995	80996	80997	80998	80999	809100	809101	809102	809103	809104	809105	809106	809107	809108	809109	809110	809111	809112	809113	809114	809115	809116	809117	809118	809119	809120	809121	809122	809123	809124	809125	809126	809127	809128	809129	809130	809131	809132	809133	809134	809135	809136	809137	809138	809139	809140	809141	809142	809143	809144	809145	809146	809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Although the search for a cure for cancer is still in its early stages, it may be implemented by the year 2000. The search for a cure for cancer, as well as other diseases, is very much a priority.

the following reaction was observed:  $\text{CH}_3\text{COOH} + \text{NaOAc} \rightarrow \text{CH}_3\text{COONa} + \text{H}_2\text{O}$ . The reaction was carried out at room temperature in a sealed tube. The reaction was complete in about 10 minutes. The product was isolated and identified as sodium acetate.

The company, while considering the suggestion, has no objection to the use of its oil, asphalt or tar products. Other companies may be available. The machine carrying tank will be required to be clean.

卷之二十一

4.  $\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$

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—*Journal of the American Mathematical Society*, Vol. 13, No. 3, May 2000, pp. 721–734.

If the first column of the last row (row 20) should be selected, then /columns 20 - 13/ will be deleted from the system. This is because enough inactive variables comes from the first 13 columns. The remaining 13 columns of the economic factors will be used to calculate the objective function. The selection rule is pretty under-

the condition that the number of linear programming technique is less than 10.

The next step is to calculate the contribution of each alternative on our objective function. If the contribution is negative, then no iterations are necessary and the solution is obtained.

#### 3.3.3.3. The final solution

After the above steps, we can obtain three different conditional

solutions. In the first case, we will obtain, i.e., we know only the sales volume of the first product, that the main obtained by the first plant of the plant capacity is 1000000 kg. The second plant of the plant capacity is 1000000 kg. The third plant of the plant capacity is 1000000 kg. The last plant of the plant capacity is 1000000 kg. (See Table 3).

The second case is similar to the first one, if this has been computed directly from the first plant of the plant capacity. The output of the system does not change. The third case is computed in the same manner, without changing the output of the system.

It is clear that the first case is the best solution of the system, that is, the first plant of the plant capacity is the best plant for chemical production. This is due to the fact that it increases the profitability of the system.

	$\frac{1}{2} \rho_1^2$	$\frac{1}{2} \rho_2^2$	$\frac{1}{2} \rho_3^2$	$\frac{1}{2} \rho_4^2$
Polyethylene	0.0	0.0	0.0	0.0
Polyvinyl chloride	0.0	0.0	0.0	0.0
Acetone	0.0	0.0	0.0	0.0
Polyvinyl Chloride	0.0	0.0	0.0	0.0
Toluene	0.0	0.0	0.0	0.0
Polypropylene	0.0	0.0	0.0	0.0
Chloroform	0.0	0.0	0.0	0.0
Propylene oxide	0.0	0.0	0.0	0.0
Ethylenic from propylene	0.0	0.0	0.0	0.0
Investigation mill.	10,3	7,1	10,3	10,3
Objective function	12,87	22,55	12,87	12,87
Average value of objective function, related to 1 ton product	0,1625	0,2255	0,1625	0,1625

## Effect of Temperature on the Mechanical Properties of Polyacrylate Copolymers

The mechanical properties of polyacrylate copolymers were determined at various temperatures by means of a Universal Testing Machine.

The temperature range of the test was from -10°C to 100°C. The temperature of the bath was controlled by a thermometer which was calibrated before each test.

The temperature of the bath was increased or decreased at a rate of 1°C per minute.

The temperature of the bath was held constant for 10 minutes before the test was made.

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The temperature of the bath was held constant for 10 minutes before the test was made.

selected, i.e., some of the variables must be assigned values before the program can proceed.

Conclusions

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Figure 1.

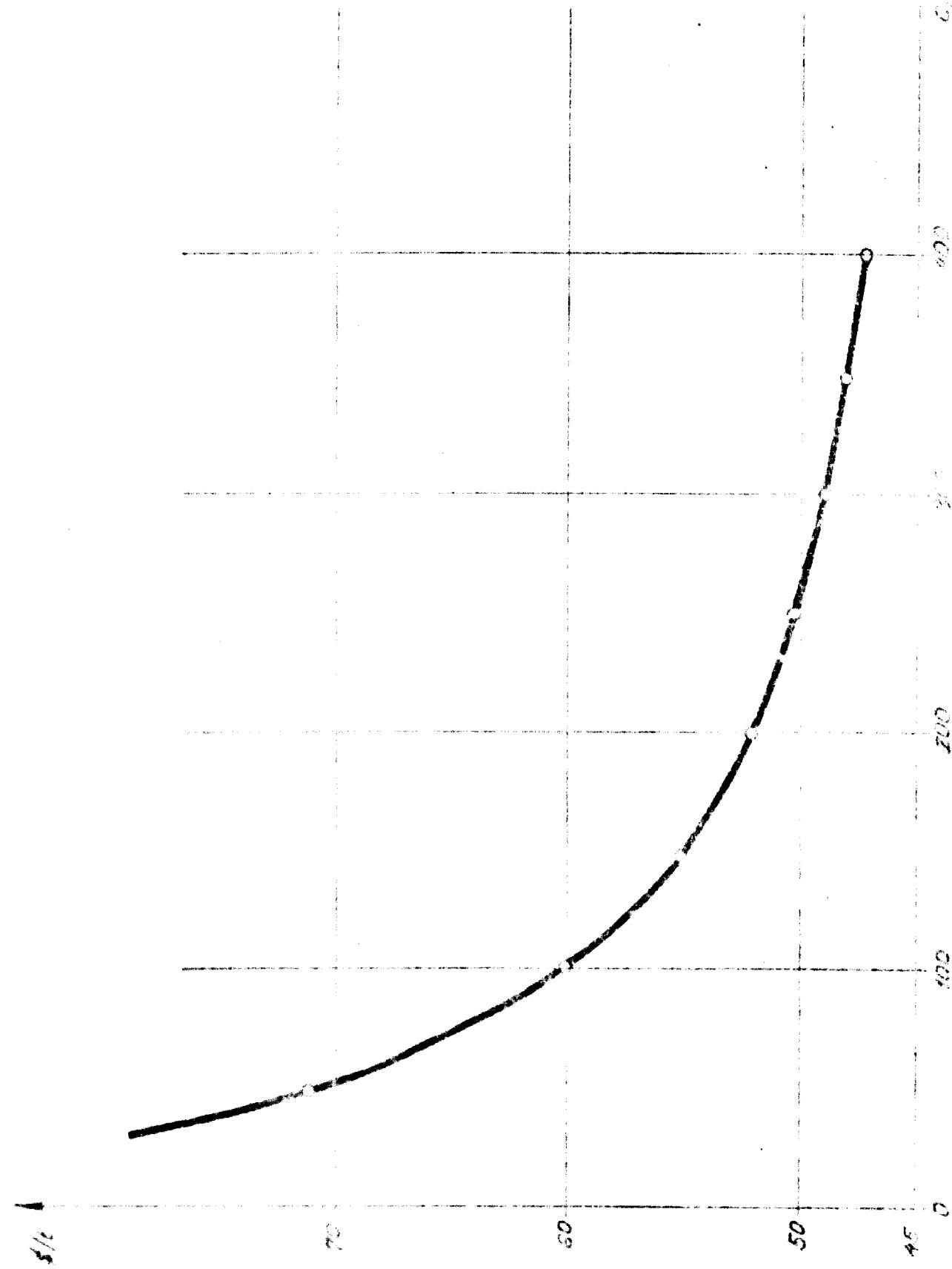
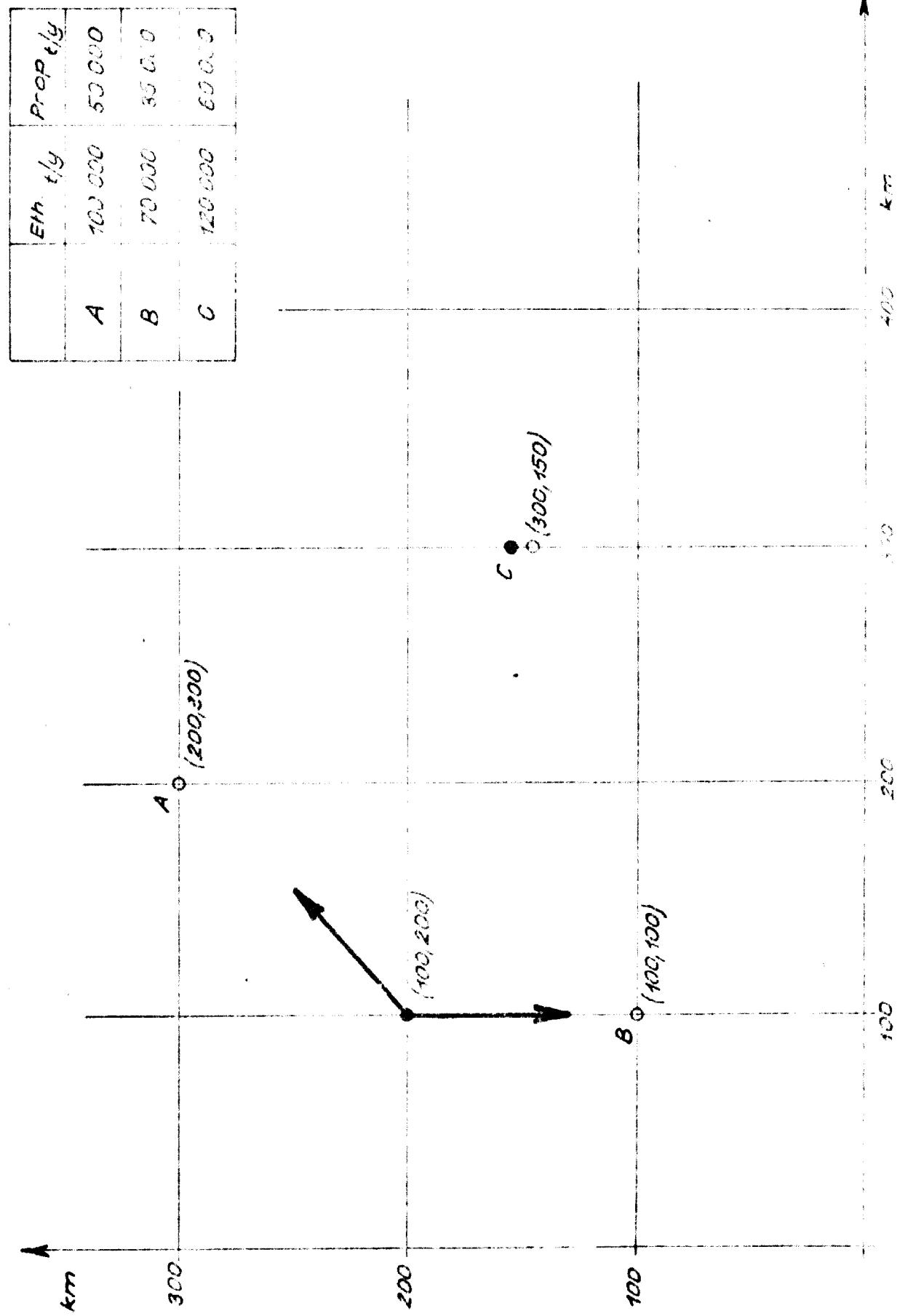
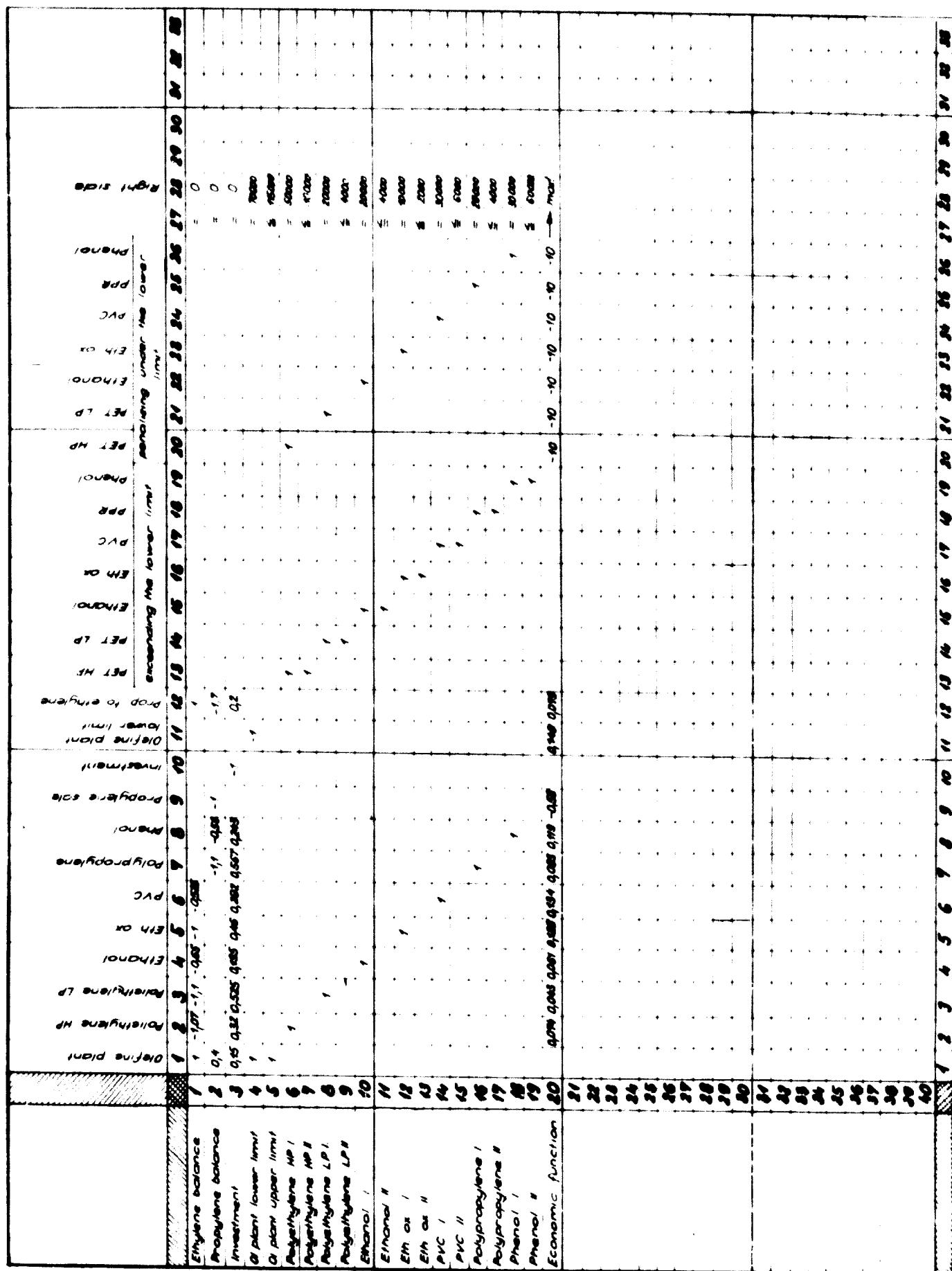


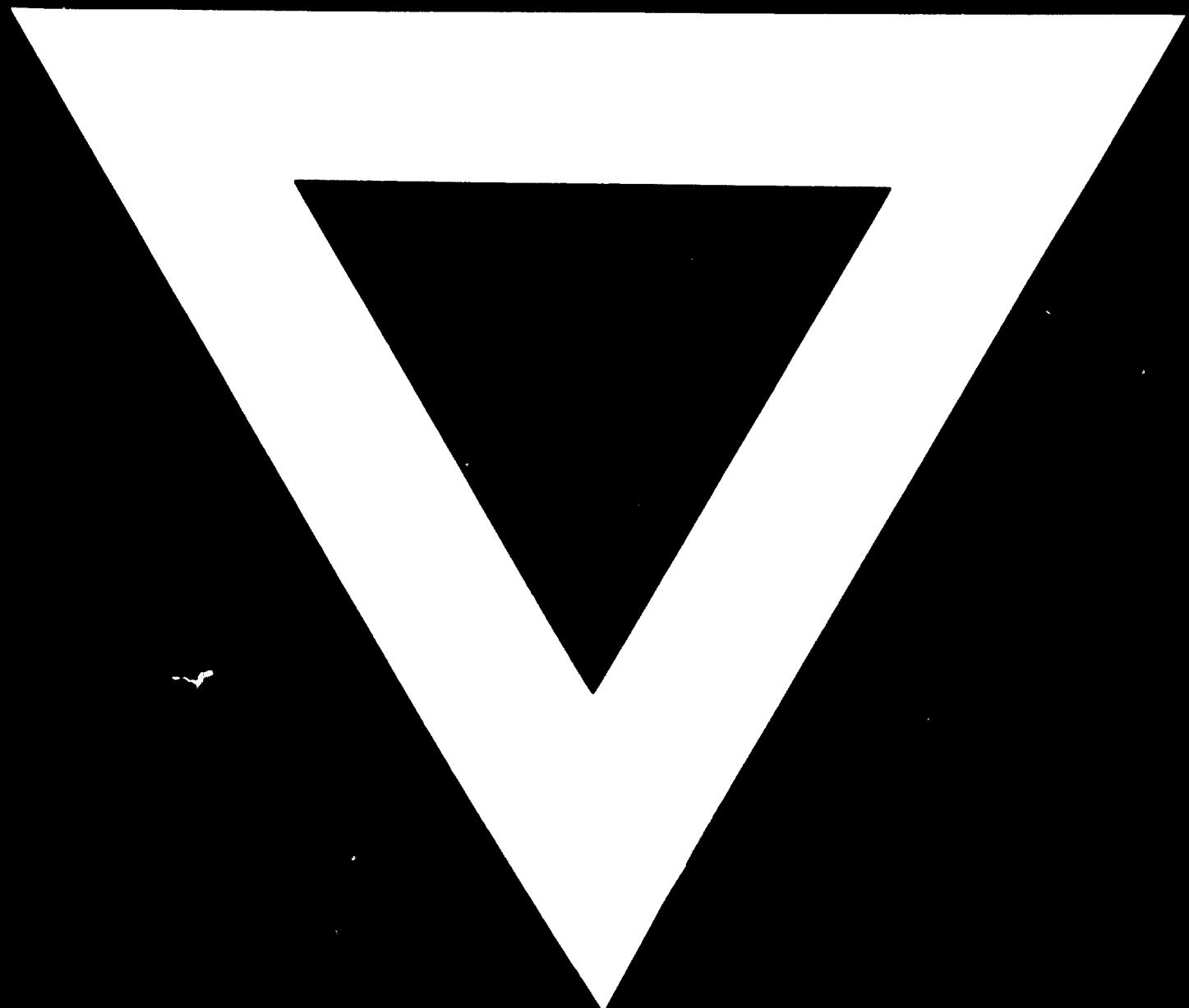
Figure 2.



*Figure 3*



*Figure 4.*



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