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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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REDEVELOPMENT IN THE UNITED STATES: A CASE STUDY FROM COLORADO

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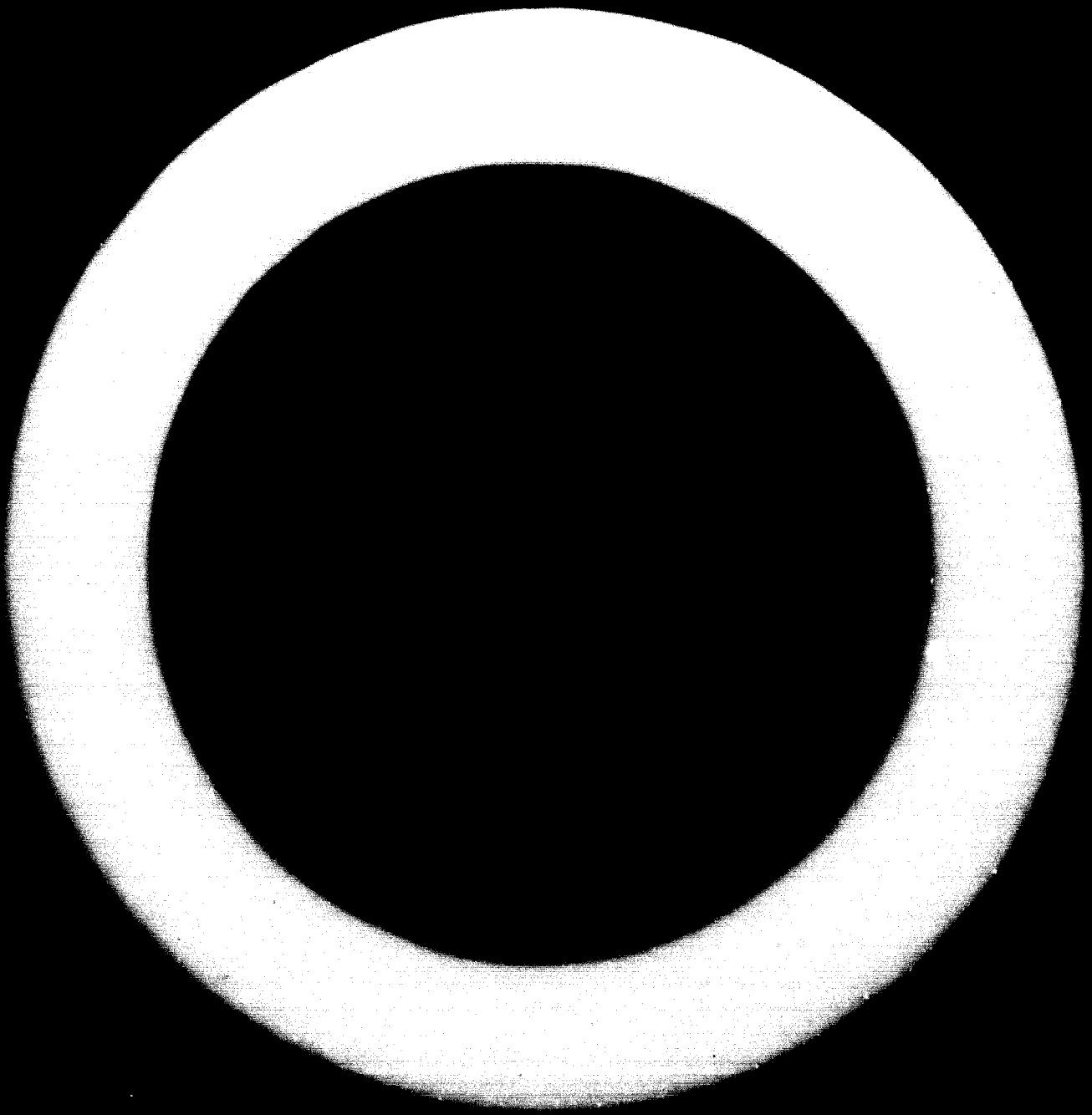

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Expenditures on research and development in the United States are currently growing faster than the economy. In 1965 the total was estimated at U.S. $21,000 million. Of this sum $15,000 million were financed by the Federal Government, $5,500 million by industry, and $500 million by universities and other non-profit organizations. The research was carried out primarily by industry to an amount of $15,500 million using government grants to supplement industrial budgets. Government laboratories carried out $3,000 million in research projects and non-profit institutions, including universities, $2,500 million.

The largest industrial concerns, for example, General Motors, or the major Government research installations, for example, the central laboratories of the National Bureau of Standards, establish their own research centres. Much of the remainder of the United States research is carried out by institutions whose location has shown, over the past twenty years, a trend towards concentration around major research-oriented universities. Government-financed laboratories are likely to be established in the same area - either operated by or affiliated with a university. This educational and research activity both attracts and generates privately-sponsored

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Mr. J.E. Stepanek, the author of this paper, has served as an official of the United Nations Relief and Rehabilitation Agency, a technical assistance expert (industrial engineer, small-scale industries) under United Nations Technical Co-operation Programmes, and a consultant to the Secretariat.

research institutions and industrial concerns.[1] Geographically concentrated and functionally related groups of this type have been termed "science-industry complexes."

Research parks for scientific institutions, laboratories and research centres and industry have become integral parts of science-industry complexes. Their objective is both to facilitate growth by providing developed land and to facilitate interactions inside and outside the parks by assuring a location in close proximity to government and university sponsored research.

Establishing a Science-Industry Complex

The three largest science-industry complexes in the United States are located in the Boston area, the Palo Alto - San Francisco Bay area, and around Baltimore.

In the Boston area approximately four hundred technically-oriented firms have been established or have been attracted by the research carried out at the Massachusetts Institute of Technology, Harvard University and affiliated government laboratories. Approximately half that number are located in the Palo Alto - San Francisco Bay area, near Stanford University or the Berkeley Campus of the University of California and approximately twenty firms in the Baltimore area around Johns Hopkins.

The widespread interest generated by the first successful science-industry complexes has led to both public and private actions to establish new complexes. The initiative of Duke University, the University of North Carolina and North Carolina State University has resulted, for example, in the establishment of a 5,000-acre (2,000-hectare) research park and the beginning of a science-industry complex. Similarly, the Denver-Boulder area of Colorado with four universities plus six Federal Government-sponsored research institutions has the base for a science-industry complex.

1/ Often the scientific research carried out at a government laboratory or at a university leads to the formation of new companies. For example, a professor or research administrator may decide to exploit the results of his basic research by designing and placing in manufacture a new product.

In 1963 the universities in the Denver area sponsored a University - Industry Liaison Conference which examined the prerequisites for a science-industry complex. More detail was added a year later through a report prepared by the University of Denver Research Institute on the essential elements for a science complex. For Colorado the report recommended the following actions to develop a science-industry complex.

(1) Universities should

-- attract key research scientists and engineers with national reputations by paying higher salaries,

-- foster and encourage additional outside consulting work by faculty members,

-- obtain additional fellowships to support the best graduate students possible,

-- nurture an environment of intellectual ferment, and

-- initiate courses on entrepreneurship through schools of business.

(2) Business and financial interests should

-- develop one or more high quality industrial and research parks,

-- make additional sources of financing available to deserving, small, science-based firms, and

-- improve the growth environment for small firms by the provision of technical services.

(3) Science-based industry in the State should

-- promote the State as the location of additional science-based firms,

-- participate in the professional growth of the community particularly through work with universities, and

-- encourage government assistance to small firms.

(4) Governmental groups should

-- provide funds for improved education in science and engineering, and

-- consider the impact of State and local taxes on the formation of science-based firms.

An inventory was taken of the existing science-oriented institutions and enterprises in the region of Denver. The region covers an area of approximately 800 square miles and has a population of 1,100,000. A summary of the findings is given in Table 1.

Table 1. Denver Region, 1965: Existing Science-Oriented Institutions and Enterprises

1. Universities

	Enrolment	1965 Research Budget (dollars)
University of Colorado	14,413	8,788,000
University of Denver	7,874	7,844,000
Colorado State University	11,848	10,134,000
Colorado School of Mines	1,442	387,000
	35,577	30,153,000

2. Government Laboratories

	1965 Employment
National Center for Atmospheric Research	400
Joint Institute for Laboratory Astrophysics	80
National Bureau of Standards	1200
Environmental Science Services Administration	200
U. S. Bureau of Reclamation	1600
U. S. Geological Survey	1300
	4780

3. Research and Science Based Manufacturing Industry

35 enterprises employing approximately 12,000

Designing an Industrial Research Park

In 1965 an 800-acre (324-hectare) research park affiliated with the University of Colorado was established four miles northeast of Boulder to remove one of the limitations of the region as a science-industry complex.

Preliminary investigations based on growth patterns in other areas showed that certain industrial groups were more likely to locate in the park than others. The groups are listed in Table 2.

Table 2. Probability of Location within the Park

High	Average	Low
Aircraft and aerospace	Other electrical equipment	Industrial chemicals
Communication equipment and electronics components	Other chemicals	Motor vehicles
Drugs and medicines	Machinery	Other transportation equipment
Scientific and mechanical measuring instruments	Petroleum refining and extraction	Primary ferrous products
Optical, surgical, photographic, and other instruments	Non-ferrous and other metal products	Fabricated metal products
	Food and kindred products	Stone, glass and clay products
		Paper and allied products
		Textiles and apparel
		Lumber, wood products and furniture

Location criteria for research laboratories were first obtained from a recent study made by the State University of New York at Buffalo (Table 3) and then applied to the park (Table 4).

It was recognized that the location of the park had certain advantages because of the prixímity of university and government research, and of a physical and cultural environment attractive to scientists and administrators. On the other hand the park was in a region not yet recognized as a national research or manufacturing centre and one far removed from any other science-industry complex.

Table 3. Percentages of All Research Laboratories Indicating Specified Opinions on Location Factors

Factor	Percent Checking Each Factor		Percent Checking Present Location	
	"Very important"	"Little or no Importance"	"Favourable"	"Unfavourable"
1. PROXIMITY TO:				
a. Company headquarters	35.2	15.4	72.6	10.8
b. Company plants	45.4	11.7	74.5	5.7
c. Important customers	11.5	48.5	36.6	7.2
d. Other research laboratories	8.5	49.7	41.4	8.6
2. PROXIMITY TO INSTITUTIONS OF HIGHER LEARNING FOR:				
a. Availability of faculty members as consultants	18.1	31.3	53.5	5.8
b. Advanced courses for staff	54.5	7.2	65.4	17.3
c. Recruitment of new staff members	36.4	19.4	48.1	12.2
3. COMMUNITY CONDITIONS:				
a. Existence of local chapters of scientific societies	27.9	10.9	71.3	7.6
b. Suitable housing	74.1	1.8	64.2	11.9
c. Good local schools	67.3	4.2	76.1	1.9
d. Cultural activities (music, art, theatre, etc.)	32.1	9.1	62.7	9.5
e. Recreational opportunities	27.7	6.6	72.2	4.4
f. Weather	9.2	26.2	29.7	16.8
4. CONVENIENT TRANSPORTATION SERVICE TO MAJOR CITIES	56.4	4.2	64.5	9.7

Source: State University of New York, Buffalo

Table 4. Evaluation of the location of the proposed Research Park

Degree of Importance	Location Criteria	Rating of Location of the Park
Primary	Access to academic institutions	
	- universities with graduate programmes	Good
	- secondary and elementary schools of quality	Good
	Availability of personnel	
	- professional, including ability to attract from elsewhere	Excellent
	- technicians and supporting personnel in the vicinity	Fair
	- suitable housing	Fair
	Community conditions	Excellent
	Proximity of home office, or of production operations	Poor
Secondary	Transportation facilities	Good
	Research atmosphere or professional environment	Excellent
	Quality sites	Excellent
Tertiary	Supporting services	Fair
	Recreational facilities	xcellent
	Availability of suitable buildings	Good (potential)
	Consultants	Good
	Markets	Poor
	Taxes	Fair
	Weather	Excellent

An estimate was made that manufacturing concerns with gross annual sales in the range of $10 to $25 million were most likely to establish research and development laboratories at a research park. Larger companies were more likely to develop their own sites for research facilities. Smaller companies were less likely to have research budgets large enough to justify separate installations. However, there are a growing number of small research companies undertaking contract research which are likely candidates for location in a research park.

The preliminary investigations also showed that companies in existing research parks received technical services from each other, through activities of government and university laboratories, and by the establishment of new service companies, such as scientific glassware. In no case, however, was there evidence of studies being made to determine the priority services which science - oriented manufacturing or research companies would like to have provided for them. In 1965 such a study was undertaken with reference to the proposed industrial park in Colorado. Its objective was to identify those services which should be provided either by the University of Colorado or by private initiative in the area of the research park.

Through a questionnaire sent to the directors of 200 industrial research laboratories, the requirements of companies planning to settle in a new research park were determined.

Identification of Services

The respondents to the questionnaire were co-operative in identifying the priority to be given to 32 services. The results are presented in Table 5.

Table 5. Services [illegible] regard[illegible]

Technical services	Priority rating (percentage of replies)	Convenience services	Priority rating (percentage of replies)
Computer	61	Restaurant	73
Machine shop	51	Banking	63
Glassblowing	42	Hotel	49
Carpentry shop	37	Postal station	39
Chemical analysis	28	Protective service	33
Sheet metal	25	Gasoline station	31
Calibration	22	Conference centre	30
Plating	22	Janitorial	25
Instrumentation	21	Travel bureau	24
Electronics design	10	Reproduction	22
Optical instrumentation	9	Conference rooms	21
Operations research	6	Auditorium	18
Packaging	4	Barber shop	16
Ultrasonic	4	Convenience shopping	15
Antenna design	0	Rent-a-Car	12
		Stenographic service	4
		Employment agency	4

Particular attention was given to the services designed which normally would be provided by a university. The response appears in Table 6.

Table 6. Services Required from a University

Service	Percentage of Replies Listing the Service	Percentage - Ranking the Service First
Library	85	52
Admission to symposia and seminars	85	12
Low tuition charges	66	15
Joint appointment on faculty or research staff	48	4
Ticket preference for cultural events	24	1
Receive university publications	21	0
Parking	12	1
Ticket preference for athletic events	4	0

One additional service, the provision of incubator space for young research and development companies, was studied. This information was essential to the University of Colorado which was contemplating to provide such a space on a non-profit basis. It was considered that, to be economical, the building should be designed for multiple occupancy and should probably be multi-storied. The study based on interviews and visits to other industrial and research parks which had provided incubator space led to the recommendation that such space was highly desirable in the proposed park. The recommendation was made that the University of Colorado should proceed with its plan for non-profit incubator space as part of the research park. The first buildings to be constructed should be "building blocks" that could be added on to as demand developed. The initial building should be no more than two stories high and should cost no more than $20 per square foot. The variety of needs as to utility services could not be estimated: therefore, the suggestion was made that no special utilities be installed initially but that provision be made for their installation as required by each client. The market appeared to warrant an initial incubator building of approximately 30,000 square feet (2,787 square metres). The tenants would require from 1,000 to 3,000 feet (93 to 279 square metres) each initially. It was believed that once their needs went to 5,000 square feet (464 square metres) they should be requested to move out into full-cost space, probably in individual buildings. The period of "incubation" was taken as approximately five years. In other words, subsidized facilities should not be provided indefinitely.

Location of Services

Three areas were identified as the preferred locations for technical and convenience services.

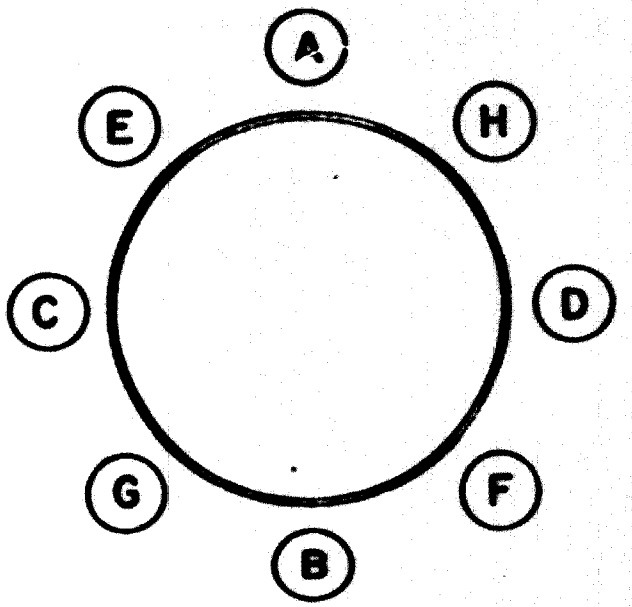
It was recommended that non-profit services, such as library, computer and incubator space, be located on a University Research Campus. (later the University of Colorado did acquire a 52-acre (21-hectare) central tract from the research park for this purpose. The objective was to test out and perfect services which later could be made available to the entire State of Colorado).

The commercial services were recommended for two locations. One group should be established in an area set aside for this purpose on the research park. (Later, 36 acres (15 hectares) were allocated for commercial services). The commercial services not located on the research park were to be distributed over the science-industry complex.

It was strongly recommended by the companies responding to the questionnaire that the research park should not take the initiative in establishing the commercial services. Thus it is anticipated that private initiative influenced by market forces will determine which services will be located at the park and which in neighbouring communities.

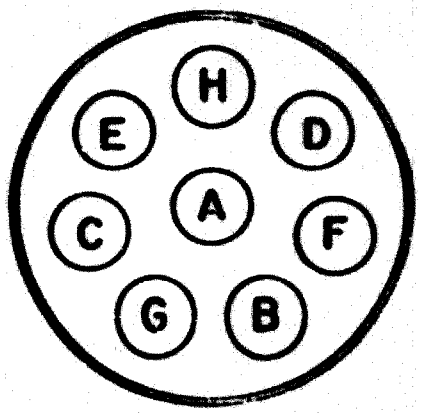
This approach is in contrast to that of research parks which depend wholly on outside concerns for services and those which attempt to provide all services within the park. Chart 1 illustrates the possible approaches.

Chart 1. Approaches to Planning Services for Research Parks



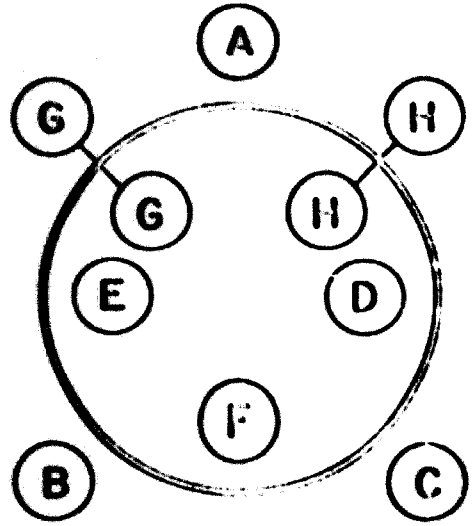
Research Park Using Facilities of Surrounding Science Centre

Most of the research parks planned to date have been designed primarily to provide sites for new research and development firms which would utilize the scientific facilities in the surrounding area. This is least expensive in terms of initial outlay and there establishment of the park close to the supporting facilities is practical. In large metropolitan areas where scientific resources are numerous and widespread, several research parks may rely on the same basic facilities.



Self-Contained Science Centre and Research Park

While there are few examples as yet, some observers believe the self-contained science centre is the plan for the future and will offer important advantages over the research park which is nothing more than a real estate venture. In this approach, multi-million dollar facilities are first built at the core of the park and additional activities are located around this nucleus.



Recommended for the Proposed Research Park

A compromise between the two other approaches is recommended for the proposed research park. This plan uses the assets of the neighbouring area, encourages private enterprise, and limits the capital investment involved.

Symbols A through H correspond to different types of services such as those listed in Tables 5 and 6, which may be grouped in different ways in or around a research park.

Manufacturing within a Research Park

The research park under review was designed to accommodate light manufacturing as well as research and development companies plus the services essential for their growth. Other research parks have also found it desirable to include manufacturing. A research park in California was designed initially to include manufacturing along with research, development and service industries. Both a research park in North Carolina and one outside of New York City found that an original plan to exclude manufacturing had to be abandoned. In all cases, however, it was found that only science-oriented manufacturing companies were likely to settle in a research park.

Many small manufacturing companies, unable to finance significant research of their own, locate in a research park.

Many small manufacturing companies, unable to finance significant research of their own, locate in a research park within a science complex because of the proximity of government laboratories and other sources of research assistance.

Other companies wish to have their research and manufacturing in close proximity. They want to have the manufacturing facility in the same area if not in the same building.

Medium-sized manufacturing companies with a large proportion of technical personnel may select a research park because of the stimulation afforded by contacts with other technicians.

Economies of scale in the design of research parks favour the inclusion of manufacturing enterprises since the latter require at least fifteen times more land than research facilities.

The design of the research park under consideration separates in two areas the activities predominantly concerned with research or development from those predominantly concerned with manufacturing.

Present location of land by use is as follows:

	Acres	Hectares
Research and development	200	81
Light manufacturing	500	202
University-sponsored non-profit services	52	21
Commercial services	36	15

It is estimated that by 1990 employment in the above tracts will exceed 20,000.

Conclusions for the Developing Countries

The principles underlying this project and the growing science-industry complex of which it is a part are pertinent to the developing countries. The following conclusions should be further studied for possible development of research parks in these countries.

(1) The rapid increase in research expenditure in the United States and in other industrial countries may need to be paralleled in the developing countries. Their need is for an additional applied research and development effort - not for basic research. The results of the latter are not dependent upon the environment of use and can readily be transferred from country to country. On the other hand, it is becoming increasingly difficult to transfer technologies - the results of applied research - as the economic and technological gaps widen between many of the developing and the industrial countries. The developing countries acting co-operatively may have to supply a larger share of their applied research needs themselves if the industrial technologies they employ are to be appropriate to their needs.

(2) The economies of scale that give rise to science-industry complexes in the United States may be even more important factors in the developing countries where both personnel and funds are severely limited. Studies may reveal major economies by having even technically unrelated government-sponsored research institutes in close proximity.

(3) Encouragement to close interaction among industry, government research institutes, and educational facilities is important in the developing countries where in many instances organizations undertaking research tend to isolate themselves from their economics. Physical proximity is not sufficient without strongly enforced policies favouring interaction. A high concentration of government-sponsored research could not be justified by the gain to the limited number of companies which would be able to locate within the complex. However, the experience gained in perfecting the interactions within the complex would prove valuable for the extension of various forms of assistance to industry over the country.

(4) The value of studies to identify the service needs of industry would be undiminished in the developing countries. Services established without a sufficient demand - as often happens - are wasteful of resources.

(5) The actions recommended for a science-industry complex in Colorado would apply to a developing country wishing to establish modern manufacturing industry employing technologies appropriate to the environment of the country.

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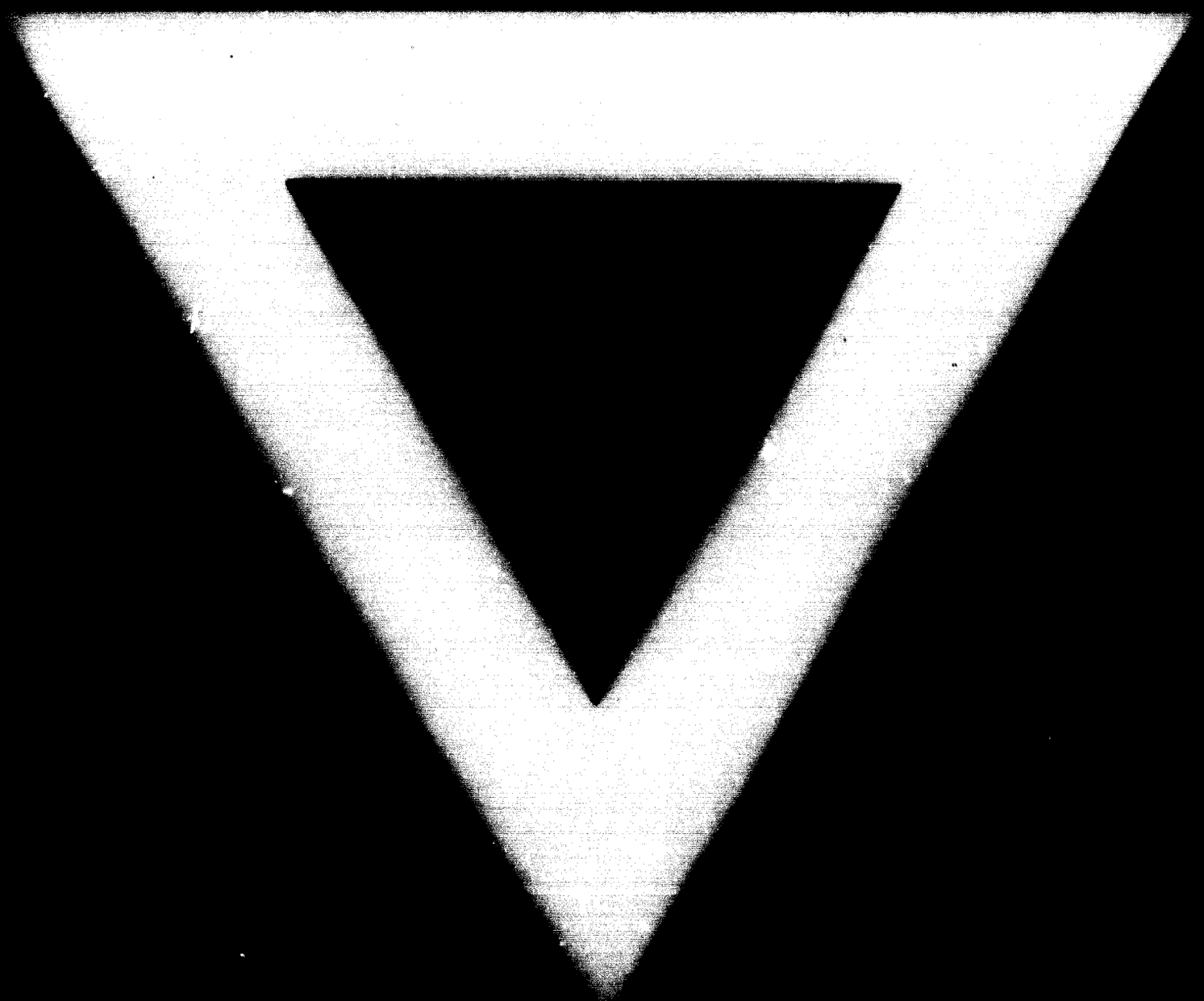

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